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163

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

VOL. VIII. NO. 7 JULY, 1958 RUPEES TWO

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TRINITY DAM DIVERSION TUNNEL

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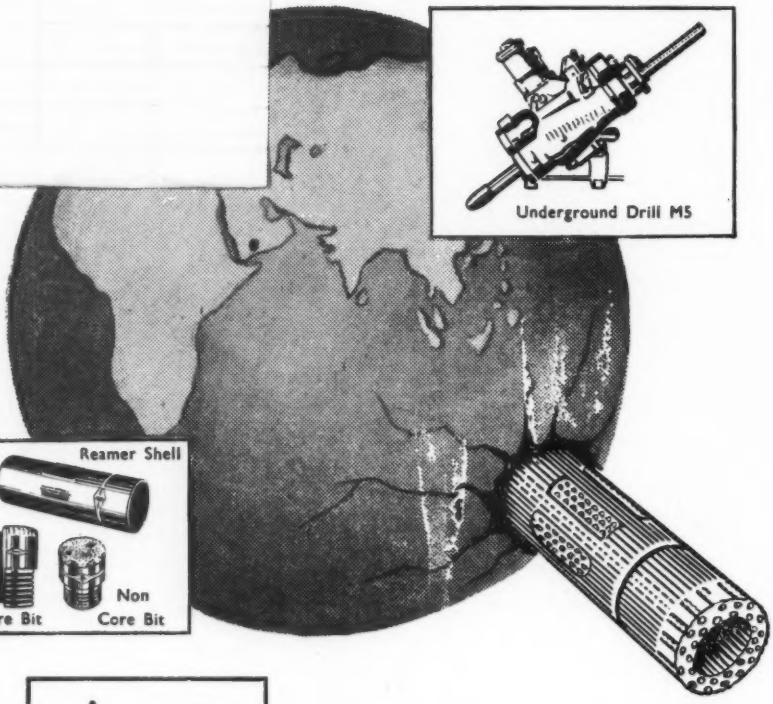
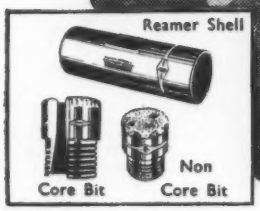
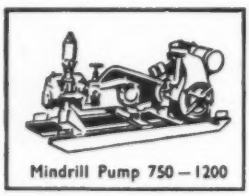


Underground Drill M5





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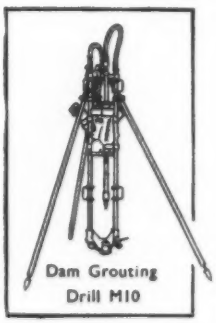
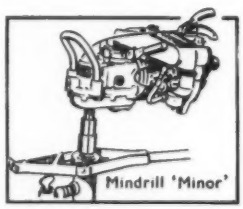
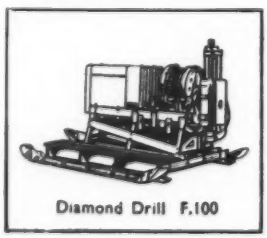


Dam Grouting Drill M10



Mindrill 'Minor'



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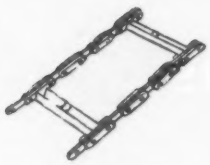
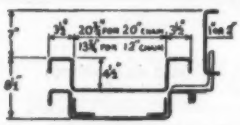
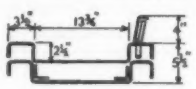


GENERAL DETAILS



STANDARD TYPE WITH OFFSET SPILLPLATE

METHOD OF APPLYING "ZEDD" LIDS



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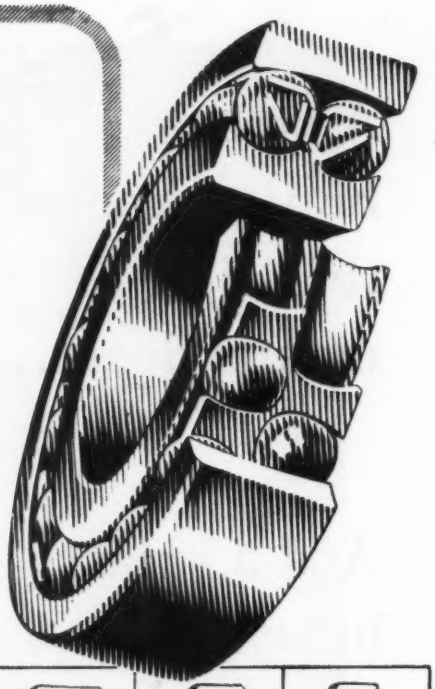

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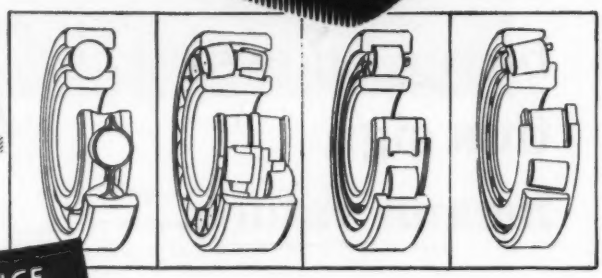

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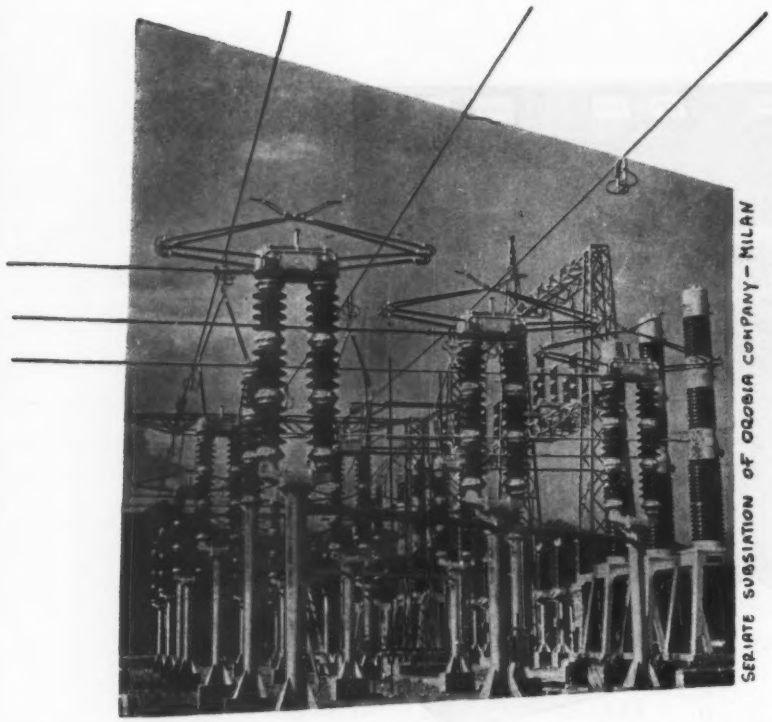

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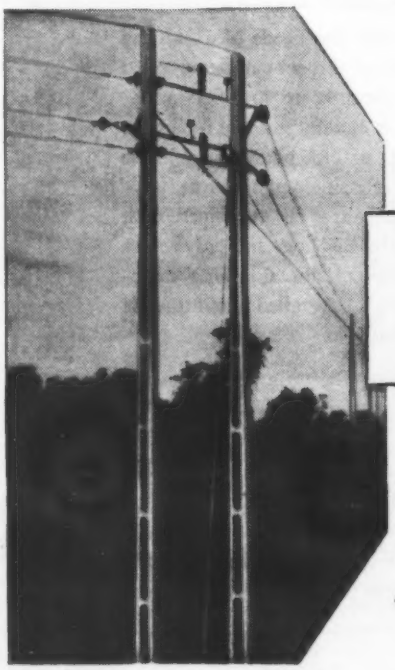

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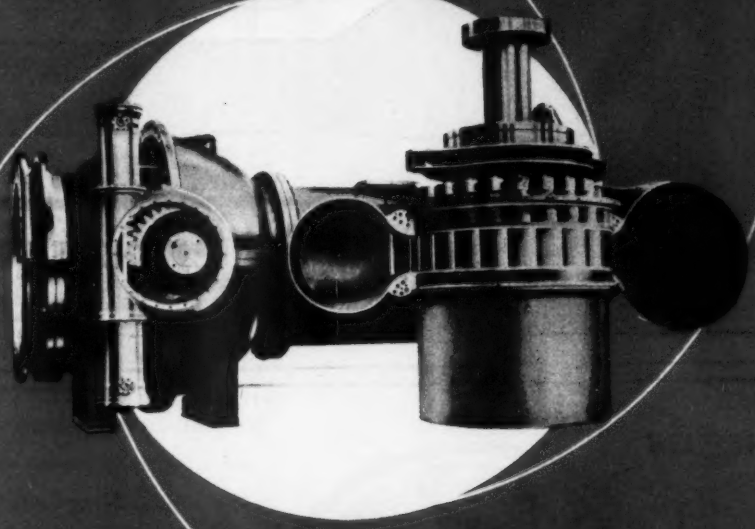

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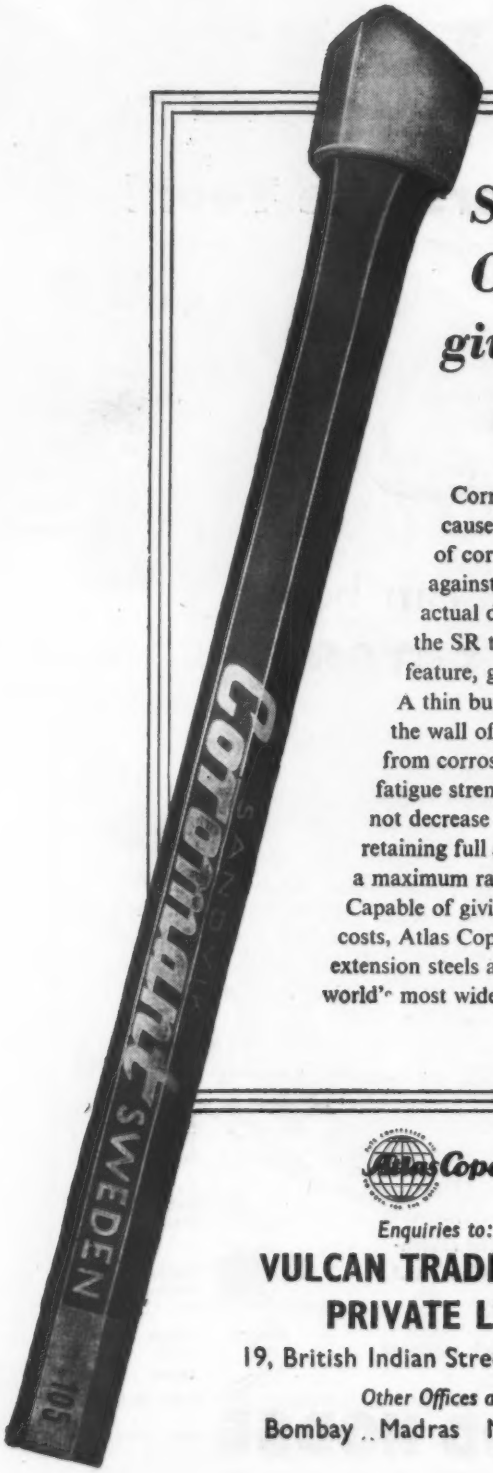

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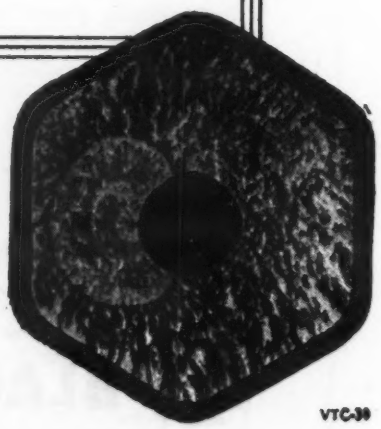

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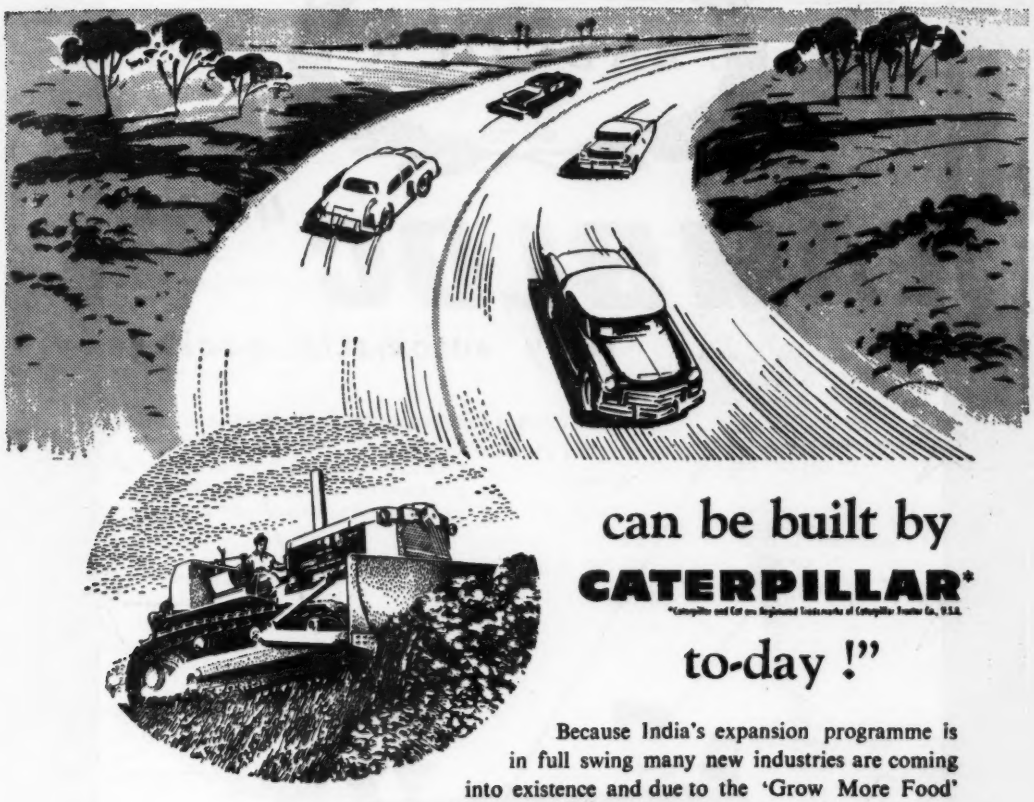

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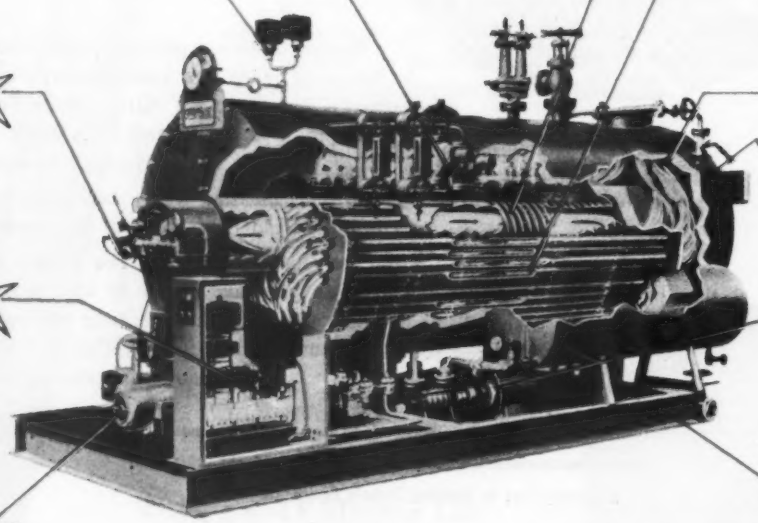

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Editor : K. K. Sinha — P. K. Menon : Mg. Editor

VOL. VIII — JULY 1958 — NO. 6

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The coming issue :

Modern Trends in the Hydro-electric Power Field *by* Dr. W. Diesendorf, Dr. Tech. Sc. (Vienna). Integrated Development of Cokeoven Gas Grid and Thermal Station of Durgapur project *by* A. K. Bhaumik, Chief Engineer, Electricity, Govt. of W. Bengal. Neyveli Lignite Project. Efficiency of Construction Equipments *by* T. P. Marik, Chief Engineer, Martin Burn Ltd. Flow-net : Its Construction and Application *by* Prof. R. M. Advani, Professor of Civil Engineering, and Prof. Alam Singh, M. B. M. Engineering College. Dams Across Valleys in Central Germany *by* Gerhard H. Kegal. Mandira Dam at Rourkela.

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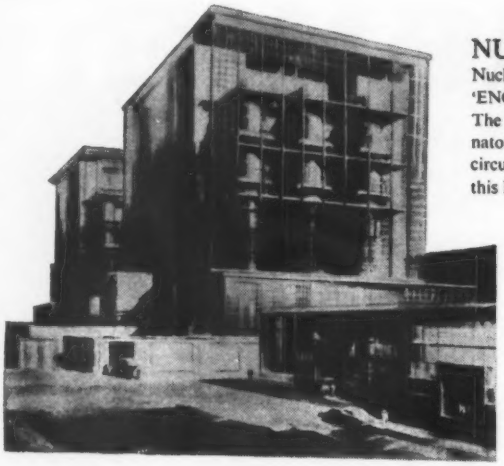
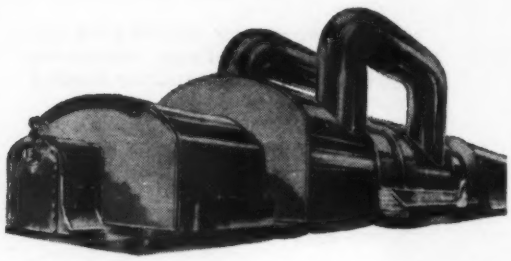


NUCLEAR. The first 500 MW Atomic Power Station (the world's largest Nuclear station) is under construction at Hinkley Point, U. K., by the 'ENGLISH ELECTRIC'—Babcock & Wilcox—Taylor Woodrow Consortium. The English Electric Company is supplying six main 93.5 MW Turbo-Alternator Sets, three 33 MW Variable Speed Turbo-Alternator Sets and a fifteen-circuit 275 kV duplicate Busbar Switching Station. The Reactors to be used at this Power Station will be of 'ENGLISH ELECTRIC' design.



STEAM. One of five 200 MW Steam Turbo-Alternators which the Company is supplying for the High Marnham Power Station, U. K. Early this year the Company received an order for two 275 MW Steam Turbo-Alternators for the New Blyth Power Station, U. K., and the sets are the two largest in-line turbo-alternators of their kind (50 cycles) in the world.

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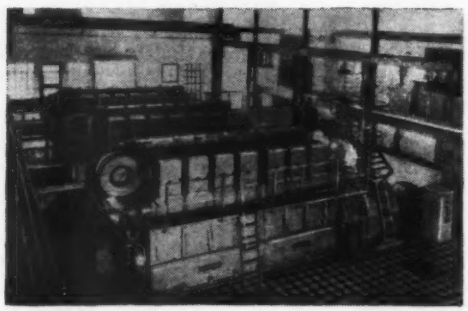

DIESEL. Three 'English Electric' Diesel Alternator Sets installed at Saateni Power Station, Zanzibar. The total output of the engines is 3,936 B.H.P. at 375 r.p.m. and the Station supplies the Island with a large part of its electricity.

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EEC-49

Power Development in the Eastern Region

We shall be glad to receive comments and discussion on this thought-provoking contribution—Editor

By P. R. SUNDARAM

Power development in the Eastern Region of India has now assumed amazing proportions. Some of the mineral deposits of commercial importance in the area are apatite for fertilisers, bauxite for aluminium, limestone for cement, chromite, china clay, asbestos, and iron, manganese and tungsten ores. Based on these, there are large industries for the manufacture of chemicals, paper, cement, iron, steel etc; and coal washeries are proposed in the coalfields of Bihar and Bengal.

With the advent of new steel factories and increased aluminium production and with the growth of subsidiary industries and with a large Railway Electrification programme, the prospects of further development and demand for power in the area will be very high. If the industrial development of this area is not to be handicapped and if the needs of the country of coal and iron are to be properly made available, planning for power development should take precedence, as employment opportunities and national developments are likely to be greatly retarded if sufficient power is not made available for the purpose in time.

Present Position

The Damodar Valley Corporation has provided a network of transmission lines in the Second Plan extending from the western districts of Bihar to Calcutta, and lines run from Bokaro to South Bihar upto the border of Orissa where the Hirakud transmission system could be connected, if necessary.

It is estimated roughly in the third year of the Second Plan there will be an additional requirement of power of 800,000 kW by 1965-66, but this figure is by no means final and as explained later a minimum of 1.5 million kW in the Third Plan seems necessary for the region, if we are not to be faced with proposals of additional generating capacity every 3 years.

Assam

The level of power development in Assam has been very low. At the end of the First Plan the installed capacity in Assam was only ·52 kW per 1000 population. Even after implementation of power development programme in the Second Fiver Year Plan, Assam will have a low installed capacity. The present figures of power consumption in Assam and the probable load forecast do not justify implementation of any major scheme of power generation. There are vast potentialities of power in the Brahmaputra basin, but this can be taken up only at a very distant date, as the requirement of power in the area are yet to be met out of their own resources and the distance of Assam from predominently power-consuming area is large.

The State had enormous Hydro Potential (about 11 million kW). Besides, large quantities of natural gas would shortly become available when new oil wells were opened up for production of crude oil. The State had also considerable quantities of coal, which however contain a large percentage of sulphur. Despite the very large potentialities of power development and the presence of abundant natural resources the present status of power development in the State is not significant.

Since the industrial development has not advanced, it may take considerable time for the demand of power within the State to grow to a size to justify large stations. The distances involved in export of energy outside are large. Therefore, the power development schemes in Assam will have to be based on utilisation of power within Assam. The programme of future power development may be on the following lines:—

(*i*) Increasing the output of the Umtru Station by building a suitable reservoir at an appropriate site upstream of the location of the present Umtru station.

(*ii*) Investigation of the Khopili Scheme and the phased development of power under this scheme.

(*iii*) The utilisation of the natural gas available in the Naharkatia area for power generation. The plans for the utilisation of the gas for power generation can be worked out only after the policy regarding the utilisation of gas (e.g. manufacture of fertilisers etc.) is decided.

It is not practicable at present to connect Assam with an Eastern grid, as it lies in an isolated area

away from the present problem. It may be feasible to consider interlinking at a later stage, say, in the Fourth of Fifth Plan.

Bihar

In South Bihar and Chotanagpur there is a well defined 132 kV grid supplying major industries like Tata Iron & Steel Co., Sahu Jain Chemicals at Dalmianagar, supply to Patna Electric Supply Co. at Patna, the coalmines in the coalfield areas and iron mines in the Singhbhum area.

The load demand in this area in the Second Five Year Plan was expected to be 140,000 kW, but it is seen now that this demand will be far exceeded. The heavy machinery plant at Ranchi requires 40,000 kW, and the development of Karanpura coalfield would need 20,000 kW. The proposed steel plant at Bokaro and coal washeries in the Jharia area viz. at Dugdha for coal requirement of the steel factories would also need large power. Certain industrial loads like Cement factories etc. in the State are not being afforded supply at present and the suppressed demand on account of these alone may aggregate to 40,000 kW in the Second Plan. The Railways have a programme of track electrification to be completed in the Second Plan and the demand on account of this alone is estimated to be of the order of 190,000 kW of which the portion in Bihar could account for 75,000 kW. Sanction has been accorded to instal one 125,000 kW turbo set at Dugdha in the area of the proposed coal washeries and steel plant. It is expected that if more power is available, the demand in the Second Plan would exceed a figure of 250,000 kW at the end of the Second Plan.

The major load in Bihar is the Tata Iron & Steel Factory at Jamshedpur. Their present demand at the end of the Second Plan is likely to be 90,000 kW. There are also indications that around the mining areas and Jamshedpur area there may be small steel furnaces operated on power. There has been some demand of power in this area, but it is not possible to meet all of them. The following are some of the major loads in the South Bihar area in the Second Plan:—

(*i*) Cement	....	43,000	kW.
(*ii*) Major industries	....	51,000	kW.
(*iii*) Coal & Mining	....	58,000	kW.
(*iv*) Industries	....	100,000	kW.
(*v*) Railways	....	80,000	kW.
(*vi*) Tubewell loads	....	15,000	kW.
(*vii*) Urban & rural load	....	20,000	kW.
		367,000	kW.

Therefore, from the present indications the Third Plan requirement of South Bihar area could easily double the Second Plan figure of 250,000 kW i.e. about 500,000 kW would seem to arise taking all factors into account.

North Bihar.

In North Bihar separate proposals have been made for a Steam Station at Barauni in the Second Plan. Since sponsoring the scheme an Oil Refinery has been sanctioned but power requirements would be needed in the Third Plan. The Barauni Scheme is now being handicapped for want of foreign exchange. Since North Bihar is not interlinked with the network of South Bihar, this problem is seggregated from the present discussion but adequate action is necessary for getting through the Steam Station A separate Gandak power project is proposed for the Third Plan.

The following are the tentative schemes that that may be taken up in the Third Plan period:—

(*a*) Completion of Barauni Thermal Station, and addition of a third 15,000 or 30,000 kW set at Barauni.

This is a scheme sanctioned in the Second Plan primarily for two 15,000 kW sets. It is possible to add additional units in the same station and combine it with the Gandak Project.

(*b*) First Phase of the Gandak Project and 132 kV line and substation from Barauni to Katihar and Muzaffarpur and Sagauli.

This is a project primarily for irrigation; but power in the canal is stated to be available. Initially 49,000 kW is proposed to be developed in the 4 sites, and tied up with the Barauni scheme.

(*c*) Kosi Power Project in the barrage.

20,000 kW of power was proposed in the Kosi Barrage. But now there is a proposal to develop power not in barrage but only in Kosi canal . The Central Water and Power Commission is investigating the scheme. The amount of power will, however, get reduced. This will serve only to supply the nearby areas round Kosi upto Purnea and Katihar, if sufficient power is available.

(*d*) Investigation of the main Barahkshetra dam on the Kosi river for a Super Power Station and carrying the power to the South Bihar areas as demands in this area may not be satisfactorily met in the Fourth Plan.

This is the original Kosi Scheme, wherein power to the extent of 1.5 million kW was proposed. Now that the load demand in the Bengal-Bihar area is high, it may be worthwhile considering the scheme again, as discussed later in this paper, in the light of the power requirement and see whether it is worthwhile taking it up further.

Sout Bihar

The following are the projects, which are tentatively suggested to be included in the Third Plan in South Bihar:—

HYDRO-ELECTRIC PROJECTS

(*a*) *Subernarekha Hydro-electric & Thermal Scheme*

Hydro capacity installed	..	60,000 kW.
Additional thermal station initially Russian plant for Hatia Heavy Machinery plant.		100,000 kW.
Later additional	..	100,000 kW.

Originally a proposal was put up for an Irrigation Project consisting of dam somewhere halfway between Gola and Ranchi. Water from the reservoir was proposed to be taken to a site nearby with an installed capacity of 40,000 kW, utilising a head of about

600 ft. Water from the tail race will be taken through a contour channel to a distance and a second Power House was proposed to be installed somewhere near the existing Hoondroo falls. The tentative capacity of the station was fixed as 20,000 kW with a head of about 300 ft. This was in addition to the irrigation project. Part of the irrigation was to benefit Purulia area. Since then the Hatia Heavy Machinery plant has been proposed at Ranchi, which requires a large amount of power 60,000 kW, for which Russians have offered two 50,000 kW sets. If this plant is located near the dam, then the potentiality of the scheme gets enhanced and water also for the thermal station would be available.

Coal for the power station would appear to be available from the Ramgarh collieries, which will be within about 10 to 15 miles of the sites. The ash content of the coal is also high, so that the utilisation of this high ash-content coal would be a good feature of the scheme.

Ultimately a 200,000 kW capacity thermal plant could be installed in the area. The matter requires further investigation.

(*b*) *South Koel Hydro-electric scheme consisting of 5 dams and 4 Power Stations* .. 300,000 kW installed capacity.

The South Koel-Hydro-electric Scheme lies in the Ranchi district and within a distance of 80 miles from Ranchi and about 100 miles from Jamshedpur. It was originally proposed to develop it in 3 stages. In view of the land development now taking place, it is proposed to take it up in two stages. The first stage will consist of construction of dams at Betarkera in the Koel river and North Karo No. 2 in the Karo river with an installed capacity of about 200,000 kW and another 100,000 kW could be installed later in two other sites.

Fairly detailed investigations of two dams and power house sites have been nearly completed and steps are in hand to finalise the report early as the scheme promises to be very advantageous.

(*c*) *Sankh Hydro-electric Scheme* .. 150,000 kW.

The Sankh River Valley scheme may yield an installed capacity of about 100,000 kW. The scheme is not yet fully investigated. It is further away by about 70 miles to the west of the Koel scheme.

(*d*) *Sone Barrage* .. .. 70,000 kW.

A barrage on the Sone river is being proposed consequent on the availability of water from the Rihand scheme in a large measure. In addition to irrigation of the Shahabad district, there is a possibility of power development in the area. Detailed investigations are yet to be carried out.

Thermal Power Projects

(*e*) Thermal Power Projects in South Karanpura area.

Consequent on the coal requirement, the South Karanpura area is being developed. It is estimated that about 20,000 kW of power will be needed in the area for prospecting alone. It is likely that a large amount of refuse coal which will not otherwise be utilised may be developed in the area. This question would require serious consideration in the Third Plan.

Therefore, the following schemes in the South Bihar and under consideration for Third Plan:—

(*a*)	Subernarekha Hydro-electric scheme with thermal station in addition. ..	260,000 kW installed.
(*b*)	South Koel Hydro-electric.	300,000 kW installed.
(*c*)	Sankh Hydro-electric Scheme. ..	150,000 kW
(*d*)	Sone barrage. ..	70,000 kW
		780,000 kW

These schemes can yield about 780,000 kW of installed capacity, but scheme (*a*) & (*b*) would seem to be likely in the Third Plan.

Damodar Valley Corporation

The Damodar Valley Corporation supplies power to the southern parts of Bihar and West Bengal. The installed capacity is proposed to be increased to about 480,000 kW in the Second Plan to meet the rising load demand, and the demand may rise to 450,000 kW in the same interval. Consequent on the Railway Electrification a demand of 190,000 kW, a steam station at Dugdha is proposed to be taken up immediately. There is no adequate provision in the Plan, therefore, to meet the growing demand even of the first two years of the Third Plan.

Substantial additional plant is immediately needed to be installed in the area, if the prospect of power shortage is not to extend into the Third Plan.

Industrial installations

A large and sizeable users' plants are now available, and these are being increased. These plants are proposed to be utilised fully, and only additional demand catered to by other arrangements. Notable installations are given in the following Table:—

User.	*Plant capacity* ('000 kW).
Sindri Fertilisers. ..	80
Tata Iron & Steel. ..	120
Coke Oven Plant. ..	60
Iron & Steel Co., Burnpur and Miscellaneous large licensees. ..	160
	420

The expected demand at the end of the Second Plan is given in the Table below:—

Expected Demand in Eastern Region

Region	*Plant capacity* ('000 kW).
D. V. C. ..	670
Calcutta. ..	350
West Bengal and Orissa. ..	120
Users' Plants. ..	300
	1,440

Providing for small standby capacity and the demand of the first year in the Third Plan, about 1.5 million kW of installed capacity will be needed at the end of the Second Plan.

Orissa

It is estimated that 180,000 kW with 70 percent load factor could be made from Hirakud Power Station. Two units of 37,000 kW and 3 units of 24,000 kW are under installation. One more 37,500 kW is sanctioned and it is possible that six units be installed in Second Five Year Plan. Lower Power House will contain three units of 24,000 kW. The system of Hirakud supplies power to the following:—

(i) Aluminium Factory near Hirakud.
(ii) Paper Mills at Brajrajnagar.
(iii) Steel Factory, Rourkela.
(iv) Cement Factory at Rajgangpur.
(v) Other factories and collieries.

It is proposed to electrify the Railway between Rourkela and Jamshedpur. The demands of the aluminium factory are 55,000 kW, steel factory 65,000 kW, Cement factory 5,000 kW, Paper Mills 10,000 kW and Collieries 2,500 kW. The provision of mining of 14,000 kW has been made. The Railway electrification load may demand about 25,000 kW and this is to be executed in the next three years. The proposals have been made for steam station with 60,000 kW nearabout Jarsaguda. Some power scheme near Rourkela area may be feasible on the Brahmani basin. Further examination of the resources of the site and increasing capacity may merit serious consideration.

Bhimkund Scheme

This is a power-cum-irrigation project. It is proposed to have a dam across the river Baitarni near Bhimkund and the main Power House is to be erected on the downstream side of the dam. A subsidiary power house utilising the tail race of the above Power House will be located a few miles below the dam. A weir will be constructed near Anandpur which will pick up water for irrigation purposes. The installed capacity of the Station is anticipated to be 2,50,000 kW. The firm power expected on this basis is 2,00,000 kW at 60% load factor. This scheme, however, appears distant from the D.V.C. grid, and the economics of interconnection has to be examined carefully.

It is estimated that, total demand on account of Orissa may be around 200,000 kW in the northern region alone. The southern region does not apear to be developed from the point of view of industrial resources and the demand may remain comparatively low for some considerable period.

It is proposed that this will be connected to the D.V.C. grid at Kharagpur. The economics of this scheme as against a thermal station near Calcutta has to be examined.

West Bengal

The total installed capacity of the hydro generating sets in West Bengal at the beginning of the First Plan period was only 3,000 kW with generation at Darjeeling and Kurseong. The Mayurakshi scheme with a new installed capacity of 4000 kW (2000 kW) is available now. The second project envisages installation of two sets each of 1200 kW. A firm power of 12,000 kW will be available and the project is expected to be completed by the Second Plan period. But owing to foreign exchange difficulty, this is likely to be extended. The third Hydro-electric in the State may materialise when the Balasun Scheme is undertaken. Preliminary investigation work in connection with utilising water power is being carried out and when the first phase of the scheme is complete 2500 kW of power will be available throughout the year and an additional 2500 kW for 8 months during the monsoon period. After these schemes are completed, about, 36,000 kW electrical power may be available.

Hydro projects in West Bengal appear to need long flume line and pipe lines to make the necessary hydraulic head for power generation. The land slide problem in the Himalayan region is again formidable factor. All these would make the capital cost of such project appreciably high. Tea gardens in that region are widely scattered. It may not be possible to supply electricity to more than 45% of the gardens economically without asking the owners of the gardens to pay for the cost of extension.

The present installed capacity of thermal generating sets in the State is 540,000 kW. These installations are mostly in Calcutta Electric Supply Corporation and the proposed Thermal Station in the D.V.C. valley. The West Bengal's old installation is comparatively small. During the Second Plan period this figure will be increased to 740,000 kW by installing two 75,000 kW by D.V.C. and two 30,000 kW sets by the West Bengal. Both of them will be located at Durgapur.

The demand on account of West Bengal includes the following:—

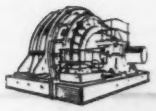
(*a*) Schemes of the West Bengal Electricity Board of Burdwan, Kharagpur, Pandaveswar (Ranigunj Coalfield area) and Bandel;

(*b*) Comparatively smaller consumers.
(i) Dishergarh Power Supply Co. Ltd.
(ii) Associated Power Co. Ltd.
(iii) Chittaranjan Locomotive Works Chittaranjan.
(iv) Hindusthan Cables, Rupnarainpur.

(*c*) Large consumers.
(i) Calcutta Electric Supply Corporation Ltd.
(ii) Indian Iron & Steel Co. Ltd., Burnpur and Kulti Works; and
(iii) Steel plant at Durgapur;

(*d*) Railway Electrification schemes for Howrah-Burdwan, Burdwan-Assansol and Howrah-Kharagpur Sections.

It seems evident that with an installed capacity of 480,000 kW of Calcutta Electric Supply Corporation and with 100,000 kW of power to be supplied by the D.V.C., the Calcutta Electric Supply Corporation and with the proposed Railway Electrification in Calcutta and suburban areas, the power in and around Calcutta will assume such proportion that it seems wise to seggregate the problem of supply to Calcutta at some stage or other and consider separately from the Eastern Region, if no economical central station with transmission is practicable.



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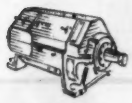
Rolling Mill Motors
for Steelworks



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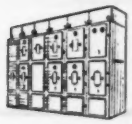

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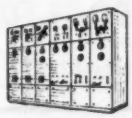

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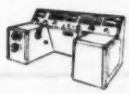
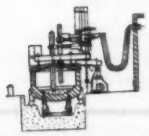


CONTROL GEAR
Desks & Contractor Boards
for Centralised Control



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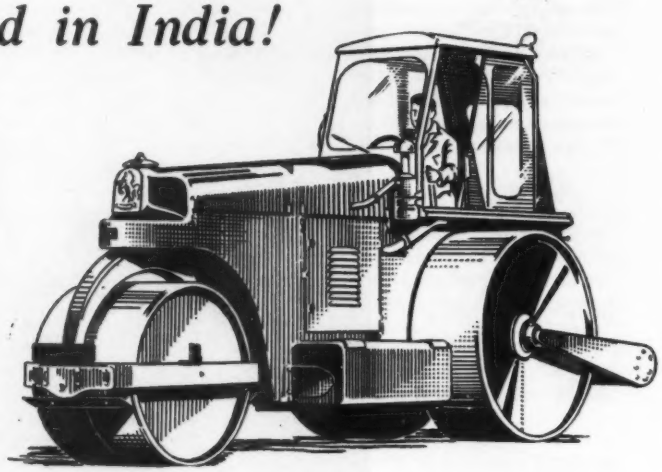

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The West Bengal's share out of the deficit of power assessed in the Eastern Region may be around 150,000 kW and 300,000 kW and 600,000 kW in 1960-61, 1965-66 and 1970-71 respectively This has resulted due to rapid growth of load in the area from Durgapur to Calcutta. The other industrial areas viz. Bandel area are in need of power to the extent of 50,000 kW for the industrial development.

The deficit of power by 1960-61 has been proposed by the West Bengal Govt. to be met by extension of their present thermal station of two 60,000 kW sets. the final project report with its implications is expected and will doubtless be considered. To cover up the deficit of 1956-66 a thermal station with three 125,000 kW sets—firm 250,000 kW is also proposed in the above report at the end of termination of D.V.C. Navigation canal in Bandel. The project report is at present in the preliminary stage.

Needs of Third Plan

For the Third Plan, however, assuming, as stated by the Planning Commission, a doubling up programme in a five-year period as a very conservative estimate, a plant of 1.5 million kW installed capacity appears to be clearly needed. Otherwise, it may fall far short of requirements.

In this connection, it is as well to bear in mind that India is expected to consume 50 kW per head per year at the end of the Second Plan. The installed capacity is expected to be 7 million kW. If, for example, the installation is to be double in the Third Plan, India should go in for an additional installation of 7 million kW in the Third Plan. Installation of large plants is, therefore, called for. If, however, the tempo of industrialisation is increased, it is likely that the further of 7 million kW will be insufficient. In case addition industrial developments take place in the Third plan and the percapita consumption is aimed at a figure of 150 units, instead of 100 units, then an additional 14m illion kW installation will be needed.

Even for doubling the capacity by installation of 7 million kW, it seems an addition of about one and a half to two million kW in the eastern region in the Third Plan period will be called for to meet the Plan requirements and keep pace with the actual load development figures so far available. In other words, from the power point of view, a super power station of the size of one and a half million kW in the area should be undertaken now, so that it may mature in time to meet the load demands. Emphasis should also be given, in addition to places in the area where large bulk power at economical rates is feasible.

Proposals

We are in the Third year of the Second Plan. Allowing time for estimates and proposals and sanctions being given, no sound proposal may be avilable for execution by the beginning of the Third Plan unless action and organisation is initiated now. Even then before the end of the Third Plan some of the resources would have been exhausted. The larger power resources that can be considered for planning the super power station, are a thermal station in the D.V.C. area, power from the Kosi and a number of smaller rivers in Bihar.

Thermal Station in D.V.C. area

In the coalfields of Jharia, Bokaro and Karanpura, a steam station of a large capacity may be feasible. Particularly with installation of coal washeries the use of middlings may contribute to cheap power. The location of the station may be within economic reach of the users of power and so may merit immediate consideration. The size of the station should be determined on the basis of the available resources in the area than on the immediate load demands, since future demands for electricity are certain.

A thermal power station of the size of 500,000 to 600,000 kW would appear to be feasible. They will probably lie in the present lay of the transmission lines of the D.V.C. and would, therefore, be economical.

Hydel Stations in Bihar and Orissa

As explained earlier the rivers Koel, Sankh, Brahmani and Baitarni contain hydro-power sites of a sizeable capacity. There is already a preliminary examination of these sites with the Central Water & Power Commission. The Bihar Government is continuing investigation on the Koel group of rivers at present and may extend the investigation to the Sankh. It would appear that about 600,000 kW would be available from the several sites on the Sankh and the Koel. The power from these sites could be connected to the existing networks, for example at Jamshedpur.

All these sites, however, require further examination before concrete proposals could be formulated to line up with the needs enumerated.

Power from Kosi

A further provision of a large single station can be envisaged from a dam at Barahakshetra. It may be recalled that one of the main arguments against the proposal for the Barahakshetra dam was that the time was not mature for considering the utilisation of power from it. From the examination made above, it would appear that a single installation of over a million kW now merits serious consideration, especially if we remember that, to construct a big scheme, two plan periods may elapse. It is also to be noted that by the time this scheme matures a number of old installations in the area would require renovation.

Assuming, therefore, a development of 1.5 million kW per plan in the eastern region, a provision of 3 million kW may be a good target to work upon to provide for the coming two plans. With the proposal of immediate utilisation of the steam and hydro-power resources mentioned earlier, we may still be left with a gap of atleast 1.5 million kW.

The question of transmission line arrangements would also require separate consideration. It would appear that extra high tension, say 400 kV, lines from the Kosi station to Bhagalpur and thence to Bokaro or Konar in Bihar on one side and to Burdwan in Bengal on the other would appear to be indicated. An interconnection with the Orissa grid may be feasible then.

Economic Proposition

It is understood, on a rough calculation that at Barahakshetra, with a slightly lower dam than originally envisaged, 1.5 million kW can be produced.

Normally Rs 1000 per kW is the reasonable cost of installation of a hydro-electric station. The lowest cost so far known in India in a large scheme is about Rs 700 per kW. Assuming Rs 700 per kW installed, the total cost for 1.5 million kW installed capacity will be Rs 105 crores. About half the cost of the scheme would be chargeable to the main dam.

If a portion of the cost is charged to flood control on account of provision for silt storage, the cost of power per kW installed will be even lower than Rs. 700. Therefore, the cost of power at the dam is likely to be the lowest in India. Hence ven from the economic angle, the proposition for a Super Power Station on the Kosi deserves serious consideration.

Atomic Power

A discussion of the foregoing would appear to be incomplete without considering the possibility of atomic power at a future date. It has been roughly estimated that the hydro-electric potentiality in India would be 40 million kW. It may be remembered that the same estimate several years ago was only 7 million. kW. On account of more data and survey the figure has increased. It may be stated that these figures are not final. Similarly, the coal resources of India is not finally estimated. In the national interest it would appear that the hydro-electric stations not only produce power but provide water for irrigation; and to a certain extent some flood control, and in view of the emphasis placed on food production, top priority should be given to all economic hydro-electric stations in upstream of river basins irrespective of the time factor of completion of stations.

The coal resources come on a different basis. They have to be integrated with the requirements of coal for industries and what is left over has necessary to be consumed for power. In this integrated economy, it is not possible to seggregate power from thermal station from the utility of coal. We have, therefore, not reached a stage when it can be said that atomic power is immediately needed.

Further the estimates given for production of atomic power is now stated to be competitive where the above coal resources are away, but these estimates are of recent origin and when it is availed in India, it is not known how the estimates will in practice result.

Subject to the above, it would be useful to consider isolated places even now in certain areas or where transport of coal is difficult or where transport has other priorities and where we have not developed the hydro-electric resources. But so far as Bengal-Bihar area is concerned, the introduction of atomic power can only be done as an experimental measure and may probably merit consideration—say for example, for a city like Calcutta, power generation may, from strategic point of view, be necessary to be near than away as an alternative for huge power requirement.

The estimates, as already stated, have only academic value and is not proved like the hydro and the steam estimates, and further the steam conditions now are not the same in a atomic station as in a modern thermal station. The efficiency will be lower than the present-day advances in thermal generation.

Continued from page 13

Construction of the 537-Foot High Trinity Dam

TRINITY DAM AND RESERVOIR

Physical Data

Dam

Type	Earthfill
Height above riverbed	465 feet
Height above lowest point in foundation	537 feet
Volume	29,100,000 cubic yards
Crest length	2,450 feet
Crest width	40 feet
Base width	2,600 feet
Crest elevation	2395.0
Maximum discharge through spillway	24,000 cubic feet per second
Freeboard	8 feet

Reservoir

Capacity	2,500,000 acre-feet at normal water elevation
Area	16,300 acres at normal water surface
Elevation maximum water surface	2387
Length	16 miles

Principal Quantities Required for the Dam, Spillway, and Outlet Works

Excavation for dam embankment foundation	3,300,000	cubic	yards
Excavation in excavation areas	4,600,000	cubic	yards
Furnishing and placing permanent structural-steel supports	900,000	pounds	
Excavation, stripping borrow pits	500,000	cubic	yards
Excavation in borrow areas and transportation to dam embankment	17,800,000	cubic	yards
Excavation, stripping quarries	70,000	cubic	yards
Excavation, overburden, in rock source and transportation to dam embankment	425,000	cubic	yards
Excavation, rock in rock source and transportation to points of final use	1,800,000	cubic	yards
Earthfill in dam embankment,			
Zone 1	9,400,000	cubic	yards
Zone 2	3,800,000	cubic	yards
Zone 3	13,400,000	cubic	yards
Rockfill in dam embankment:			
Zone 4	2,200,000	cubic	yards
Riprap	200,000	cubic	yards
Rock surfacing	100,000	cubic	yards
Furnishing and handling cement	160,000	barrels	
Furnishing and placing reinforcement bars	8,700,000	pounds	
Concrete in spillway and outlet works structures	103,720	cubic	yards

Construction of The 537-Foot High Trinity Dam

By CARL J. HOFFMAN and WILLIAM E. COLLINS

Construction began in April on what will be one of the highest earthfill dams in the world. It is the 537-foot high Trinity Dam, principal feature of the Bureau of Reclamation's Trinity River Division of the Central Valley Project in northern California. The dam and other Division structures, as authorized by Congress in 1955, will ultimately make possible the average annual transbasin diversion of 865,000 acre-feet of surplus waters from the Trinity River watershed to the adjacent Sacramento River Basin, thus augmenting the water supply of the Central Valley Basin.

The dam is being built on the Trinity River about 8 miles north of the town of Lewiston. About 29 million cubic yards of earth and rock—a Bureau of Reclamation record—will be placed in the embankment. The dam will have a crest length of 2,450 feet, a crest width of 40 feet, and a maximum base width of 2,600 feet. Trinity Reservoir will have a maximum capacity of 2,500,000 acre-feet and an active storage capacity of 2,160,000 acre-feet.

In addition to its great height and large volume, Trinity Dam is unusual in Bureau of Reclamation experience in that it consists of a combination of materials not ordinarily encountered in earth dam construction. The impervious core comprises weathered rock available in the immediate vicinity of the dam, rather than more "conventional" earth materials available at a longer haul distance. This is possible because of the size and efficiency of modern earth working equipment, which can break the weathered rock fragments to the desired size as they are placed and compacted. Materials from foundation excavation and a nearby slide area are to be utilized between the impervious core and the outer pervious zones. Sands and gravels, including tailings piled along the river from gold dredging operations, will be used in the outer zones.

First construction at the dam site began in May 1956, following award of a $1,348,000 contract to Gates and Fox Company of Burlingame, California, for construction of the 33-foot diameter diversion tunnel on the dam's left abutment. Excavation of the 2,281-foot long tunnel, which will divert the full flow of the river during construction, was completed in April of this year. The $48,928,100.52-contract for construction of the dam, which is expected to extend for 5 years, is held by a combination of the following firms: Guy F. Atkinson Company, M. J. Bevanda, Charles L. Harney, Inc., Ostrander Construction Company, A. Teichert and Son, Inc., and Trepte Construction Company, Inc. The concrete lining of the diversion tunnel to its finished inside diameter of 28 feet will be completed under the dam contract.

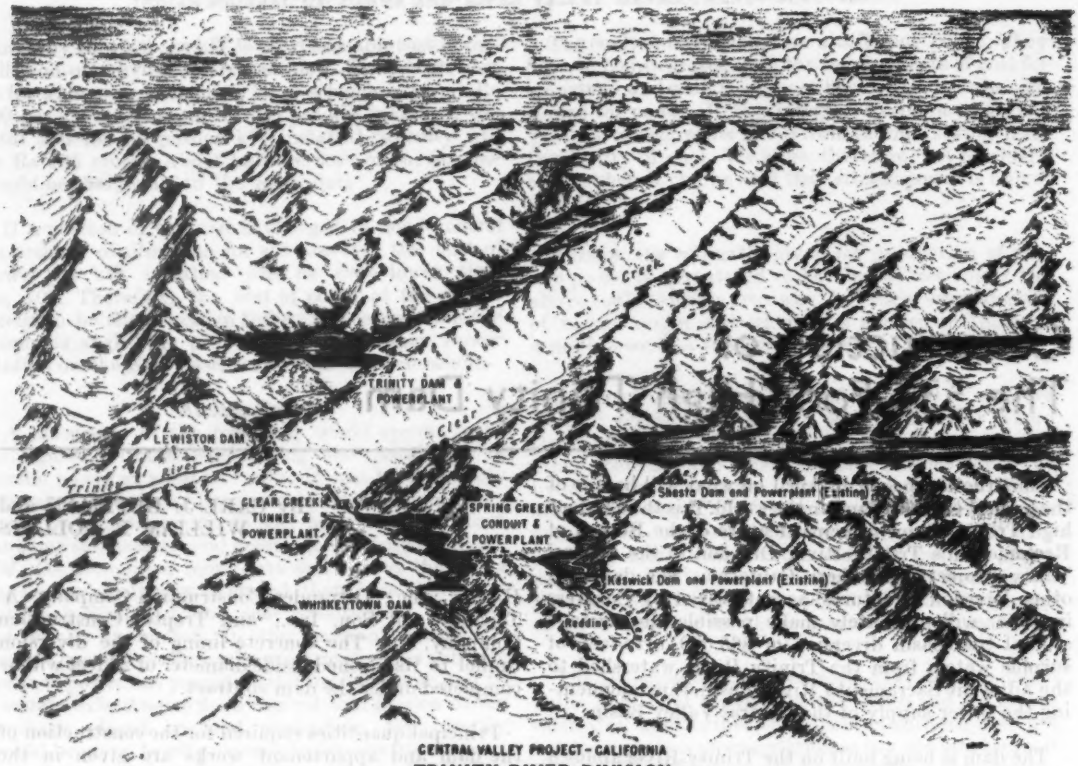
Principal quantities required for the construction of the dam and appurtenant works are given in the accompanying tabulation.

The scope of the development of the Trinity River Division and the plans for construction of Trinity Dam are briefly described in the following summary.

Plan of Development

The Trinity River Basin embraces an area of about 2,900 square miles lying between the northern-most part of the Central Valley and California's north coastral area. The Trinity River is a 130-mile long tributary of the Klamath River, which flows westerly into the Pacific Ocean. Because of the rough terrain and the extensive forests of the Trinity Basin only a

Key map of the Trinity Dam site in northern California.



CENTRAL VALLEY PROJECT - CALIFORNIA
TRINITY RIVER DIVISION

Artist's drawing of Trinity River Division showing the major features of the Division.

small portion of the runoff can be utilized for agriculture and other beneficial uses. As a result, hundreds of thousands of acre-feet of water are wasted into the ocean. The transbasin diversion will not only put this water to beneficial use but will also make possible the production of hydroelectric power.

Average annual runoff of the Trinity River at the point of diversion is about 1,100,000 acre-feet. It is estimated that no more than about 120,000 acre-feet annually are needed downstream to satisfy irrigation, municipal, and industrial users, and to provide flows for recreation and fishery needs. The yearly runoffs of the Trinity River are erratic, ranging during a 20-year period from 260,000 acre-feet to 2,550,000 acre-feet. Approximately 75 percent of the runoff results from snowmelt and spring rains occurring during the months of February to June. Trinity Reservoir will provide the storage space needed to capture this seasonal runoff and will supply hold-over storage for years of less than average yields.

As authorized by the Congress, the Trinity River Division is to be integrated operationally and financially with the Central Valley Projet. By proper distribution of the diverted water and by making maximum use of return flows and available surplus flows, it is estimated that the Trinity transbasin diversion will yield more than 1,400,000 acre-feet a year for irrigation in the Central Valley Basin.

The more than 1,700 feet of head to be created by the transbasin diversion undertaking will also make possible the development of additional hydroelectric power for the northern California region. Four powerplants, including the Trinity Powerplant to be built at the toe of Trinity Dam, are to be built as part of the diversion system. These plants will have a total capacity of slightly less than 400,000 kilowatts and will generate more than 1 billion kilowatt hours of hydroelectric energy annually. Under the Congressional authorization, the power installations may be constructed by private interests or by the Federal Government. However, no decision has yet been made by the Congress as to the construction of the power facilities.

In addition to Trinity Dam and the powerplants,

The Trinity River flowing into the intake portal of the deversion tunnel. River flow was 500 cubic feet per second July 8, 1957.

General view at the inlet end of the diversion tunnel at Trinity Dam showing construction progress on the portal and intake tower.

other major features of the diversion plan of development include Lewiston Diversion Dam, Clear Creek Tunnel, Whiskeytown Dam, and Spring Creek Conduit. Releases from Trinity Dam will be diverted at Lewiston Diversion Dam, about 6 miles downstream, into Clear Creek Tunnel, which will extend southeast to the upper end of Whiskeytown Reservoir on Clear Greek, a tributary of the Sacramento River. From Whiskeytown Reservoir, the water is to be carried east through the Spring Creek Conduit to Keswick Reservoir behind Keswick Dam, a Central Valley Project feature completed in 1950.

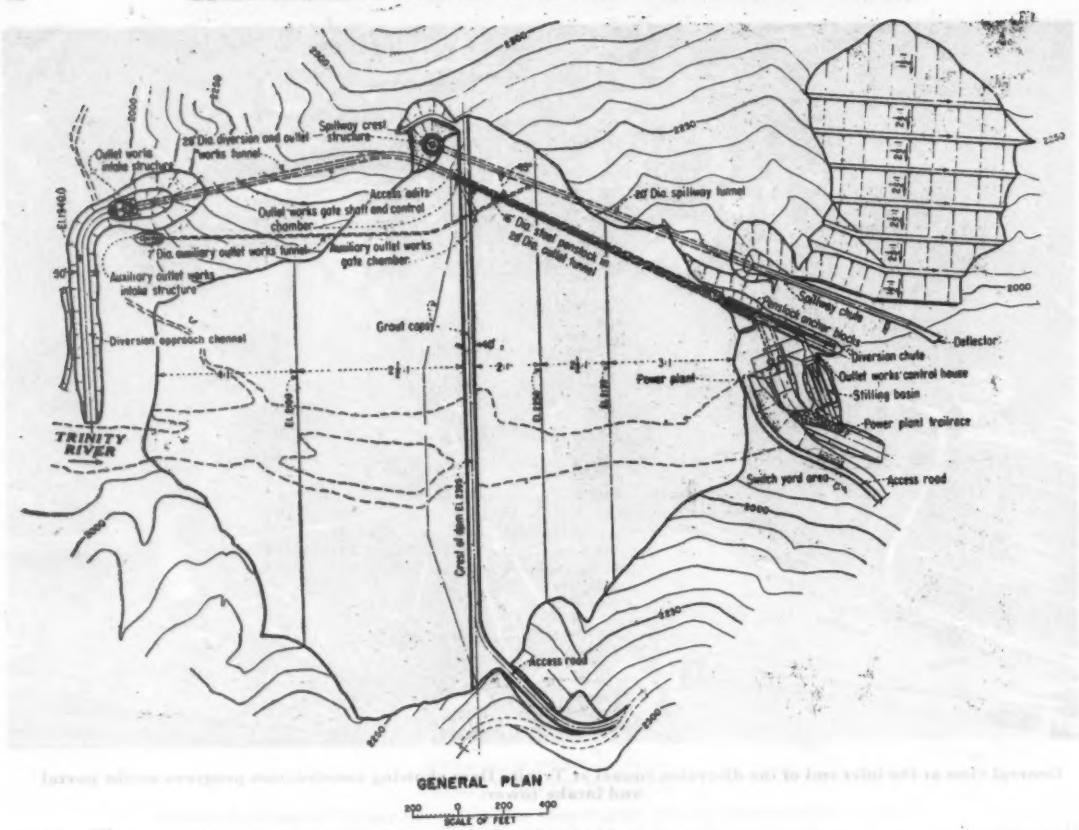
Lewiston Diversion Dam, of earthfill and rockfill construction, will be about 70 feet high and will have a vloume of about 320,000 cubic yards. The dam will have spillway and outlet facilities to meet downstream water requirements. A powerplant will be built as a part of the outlet installation.

Clear Greek Tunnel is to be 10.8 miles long and will be concrete lined to an inside diameter of 17.5 feet; it will be a pressure conduit carrying a maximum flow of 3,200 cfs. It is being constructed on a grade of 17 feet per mile and will have its outlet portal more than 500 feet above the Clear Creek streambed. The tunnel installation will include a controlled intake at the Lewiston Diversion Dam forebay, a large surge chamber near the outlet portal, and a steel penstock to convey water from the outlet portal to Clear Creek Powerplant. The powerplant will operate under an approximate head of 560 feet.

Construction of Clear Creek Tunnel began in March of this year under a $36,644,556-contract awarded to the following combination of contractors: The Shea Company, Henry J. Kaiser Company, Morrison-Knudsen Company, Inc., Macco Corporation, and Raymond Concrete Pile Company. The tunnel—a major construction undertaking—will be almost as long and nearly twice the diameter of the Bureau's longest tunnel, the Alva B. Adams Tunnel (13.1 miles long and 9.75 feet in diameter) on the Colorado-Big Thompson Project in Colorado.

As now planned, Whiskeytown Dam is to be a 278-foot high earth and rockfill structure having a volume of 4,000,000 cubic yards and will be constructed across Clear Creek downstream from Clear Creek Powerplant. The reservoir created by the dam will regulate flows from the powerplant and will retain runoffs from the Clear Creek drainage area, estimated to average about 200,000 acre-feet annually. The reservoir will have a maximum storage capacity of 250,000 acre-feet.

Whiskeytown Reservoir will provide the forebay for the Spring Creek Conduit, which will serve as the connecting conveyance structure between Clear Creek and Keswick Reservoir. The conduit, which will have its entrance about 100 feet below the normal operating level of Whiskeytown Reservoir, will comprise two concrete-lined 18.5-feet-diameter tunnels and a siphon section interconnecting the tunnels. One tunnel will be 8,700 feet long at the upstream reach of the conduit, and the second tunnel will be 3,500 feet long at the downstream reach. The intervening steel-lined siphon section will have a diameter of 17 feet and a length of 3,200 feet. The conduit will carry a maximum flow of 3,600 cfs and will operate under pressure.



Trinity Dam—General plan.

The conduit will discharge through a steel penstock into the Spring Creek Powerplant, largest of the Division's power installations, which will operate under an approximate head of 565 feet. In turn, water discharging from the plant will be released into Keswick Reservoir to augment the supply available at the Keswick Powerplant on the Sacramento River, increasing the generating output at that plant by an estimated 59 million kilowatt-hours annually.

Dam Construction

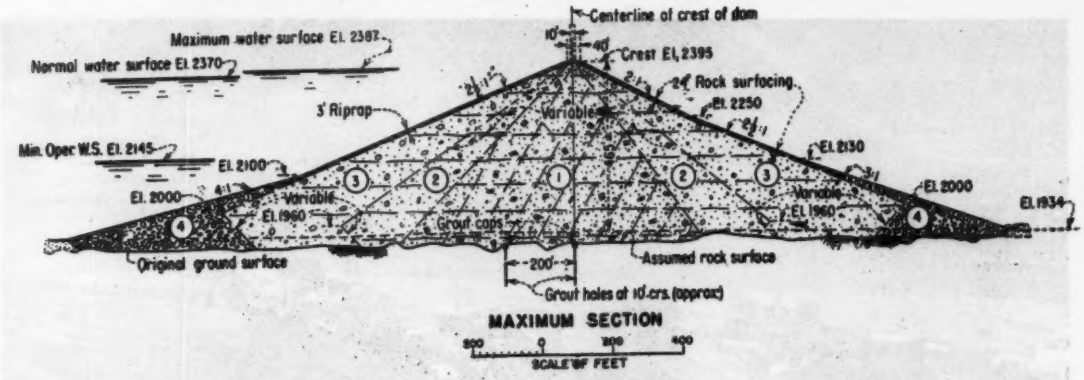
Geologically, the Trinity Dam site is favourable for construction of a high earthfill structure. In general, bedrocks in the Trinity River Region are hard, metamorphic formations. Bedrock at the Trinity Dam site is termed Copley meta-andesite or greenstone," a crystalline rock resulting from low grade metamorphism of basaltic and andesitic lavas. This rock is similar to the formstion upon which Shasta and Keswick Dams were built. Weathering of the meta-andesite is deep and severe, but much of the near surface rock is sufficiently firm to support the dam.

An estimated 3,300,000 cubic yards of materials—ranging from sand and gravel in the river channel to older, more severely weathered bedrock and residual soils on the abutments—will be removed from the dam foundation. Under the impervious zone, additional material will be removed to firm bedrock to assure a completely competent and tight contact.

The dam embankment consists of four zones of selected materials, each distinguished by its particular structural and permeability properties and by the method of placement. The center zone of the dam, containing 9,400,000 cubic yards, is designated as zone 1 and will form the impervious water-tight barrier. The material for this zone is a selected weathered meta-andesite rock to be excavated from the Copley formation. Upon excavation and placement in the embankment, this material breaks down into silty sand and fragmentary rock particles. Compaction is to be achieved by a minimum of 12 passes of a tamping roller over each 6-inch layer of embankment.

The Zone 2 portions of the embankment, which flank each side of the center impervious core, contain 3,800,000 cubic yards to fill. This zone is designed to utilize material excavated from a potential slide area on the left abutment immediately downstream from the dam, stripped material covering rock to be used in the dam, and selected material from foundation and structure excavations. In stabilising the slide area, which lies directly above the Trinity Powerplant area and the outlet channels for the spillway and outlet works, 2,200,000 cubic yards of the hillside will be removed. The material to be removed is weathered rock from the Bragdon formation of Mississippian Age, and is classified mostly as silt containing some friable gravel fragments. In the placement of the zone 2 embankment, compaction is to be obtained by 12 passes of a tamping roller over each 12-inch layer.

Both Zone 1 and Zone 2 materials when compacted have comparatively high densities. Average maximum laboratory dry densities are 110 pounds per cubic



EMBANKMENT EXPLANATION

① Selected weathered rock (clay, silt, sand and gravel) compacted by tamping rollers to 6" layers.

② Selected weathered rock (silt, sand, gravel and cobbles) compacted by tamping rollers to 12" layers.

③ Alternating layers of selected dredger tailings (gravel, cobbles and boulders), and selected dredger screenings and selected undredged sand and gravel (silt, sand, gravel, cobbles and boulders) compacted by crawler-type tractors in 18" and 12" layers respectively.

④ Rockfill placed in 3' layers

Trinity Dam—Maximum Section.

foot for Zone 1 and 113 pounds per cubic foot for Zone 2. Optimum water contents are 16.5 percent and 15.4 percent, respectively.

In developing a source of rockfill material for use in other zones of the embankment, it is necessary to remove 360,000 cubic yards of overburden from a rock quarry located about a mile from the dam site. The stripped materials is weathered Copley meta-andesite similar to that to be utilized in zone 1. The more weathered rock is to be placed in zone 1 and the less weathered in zone 2.

Zone 3 portions of the embankment which will form the pervious outer zones of the dam, contain 13,400,000 cubic yards of materials. These materials, consisting of sand, gravel, cobbles, and boulders, are to be obtained from excavations of the dam foundation and from borrow areas in the river channel upstream and downstream from the dam.

Much of the Trinity River channel in the vicinity of the dam site had been mined by bucket-type dredgers. As a result, high piles of dredger tailings are now exposed in the river channel. These river borrow areas thus yield three distinct types of material for the zone 3 embankment; dredger tailings consisting of gravel, cobbles, and boulders; dredger screenings consisting of silt, sand, and gravel, up to three-eighths-inch in size; and undregded materials composed of silt, sand, gravel, and cobbles and boulders.

The zone 3 material is to be compacted in the embankment by a heavy crawler-type tractor. Much of the dredger screenings and undredged materials exists below the water table, which will necessitate its excavation in a saturated state. Placing successive layers of the saturated material without allowing sufficient time for drainage may introduce unstable conditions under the heavy hauling equipment. To stabilize the placing, a 12-inch layer of dredger screenings or undergded material is to be alternated with an 18-inch layer of free-drainage dredger tailings.

The materials for the zone 3 embankment are being removed from the downstream borrow areas to form a deepened channel below the dam. The resulting lowered tailwater will make available more than 20 feet of added powerhead for Trinity Powerplant. Immediately below the spillway exit channel, the riverbed is being excavated to bedrock to minimize the formation of sandbars which might develop from spillway flow erosions.

The upstream and downstream toes of the dam are to be protected by heavy rockfill, designated as zone 4. The upstream slope of the dam is to be covered with a 3-feet layer of riprap as protection against reservoir wave action, and the downstream slope will be surfaced with a 24-inch layer of rock to prevent erosion of the underlying material. Rock for the zone 4 fill and for the riprap surfacings—an estimated 2,500,000 cubic yards will be required—is to be obtained from sound rock materials from the spillway and outlet works excavations and from the rock quarry. The quarry rock is the fresher and harder Copley meta-andesite.

Spillway

As a result of extensive hydrological studies of the flood potential at Trinity Dam, provisions have been made to accommodate of flood having an instantaneous peak of 160,000 cubic feet per second and a six-day volume of 489,000 acre-feet. As the reservoir area at normal reservoir water level is more than 16,000 acres, it is possible to store a large volume of the flood in surcharge storage space with only a small increase in the height of the dam. Studies indicated that raising the dam to store more of the flood was more economical than providing equivalent spillway outflow capacity, and that on the basis of cost alone, no spillway was justified. By utilizing only the Trinity Powerplant and outlet works to discharge about 6,000 cubic feet per second during a maximum flood, and considering the reservoir to be full at the start of the flood, it was determined that a surcharge of 23 feet would be required to contain the entire flood volume.

Trinity Division.—Trinity Dam:—Contractor removing the first overburden from the dam-site, right abutment upstream from the axis. Left abutment downstrem in background.

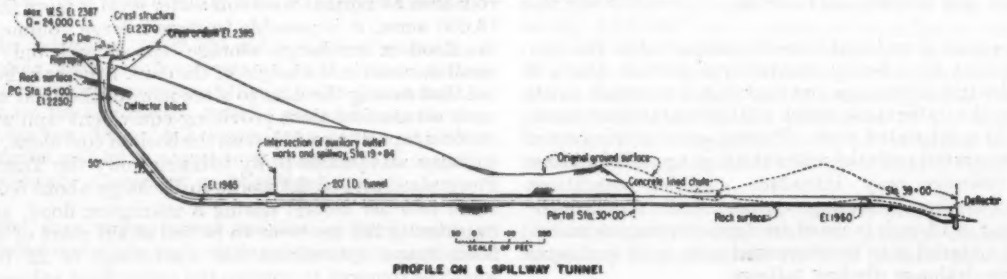
However, evacuation facilities for emptying the accumulated surcharge storage in a reasonable time were needed, so that space would be available for a recurrent flood. Accordingly, a spillway having a maximum capacity of 24,000 cfs was arbitrarily selected to provide this need. With releases from this spillway, augmented by discharges from the powerplant and outlet valves, the maximum design flood succeeded in 10 days by a flood equal in magnitude to the historic 1955 flood of record can be accommodated by storing 315,000 acre-feet of the runoff in a 17-foot depth of surcharge.

The spillway, placed in the left abutment, comprises a vertical "morning glory" inlet connected to a 20-foot-diameter horizontal tunnel by an inclined shaft. Flows up to about 22,000 cfs will be controlled by the 54-foot-diameter circular crest inlet; for greater flows the crest entrance will drown out and discharges will be controlled at the deflector block placed at the bottom of the vertical inlet leg. The tunnel beyond the deflector block will flow partly full for all discharges. The lower leg of the spillway tunnel is placed about 20 feet above the existing river level, where it connects to an open-cut chute which will guide the flows well beyond the toe of the dam. A deflector lip at the end of the chute will fan the flow and turn it upward so that its energy will be dissipated in the river channel at a distance from the end of the structure. Existing shallow depths to bedrock at the point of jet impingement should minimize riverbed erosion below the dam.

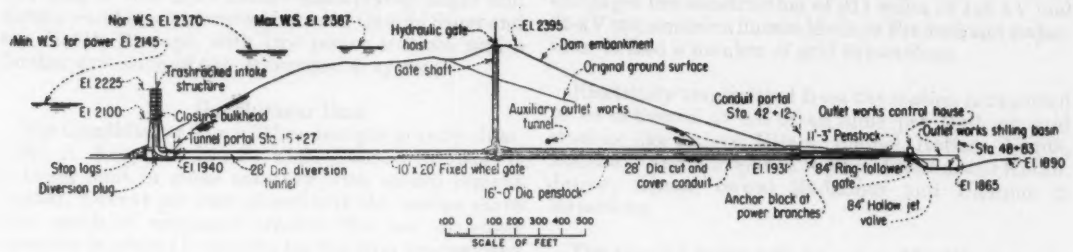
Penstock and Outlet Facilities

After diversion requirement have been fulfilled the diversion openings in the approximately 300-foot high intake structure will be plugged and a 10 by 20-foot control gate and a 16-foot diameter penstock pipe will be installed in the diversion tunnel to deliver water to the Trinity Powerplant turbines. A branch takeoff from the penstock will provide bypass outlet facilities to release water in the event of powerplant shutdown or to supplement the turbine releases if evacuation of reservoir or surcharge storage is desired. Outlet flows will be regulated by two 84-inch hollow jet valves; the energy of the flow released from

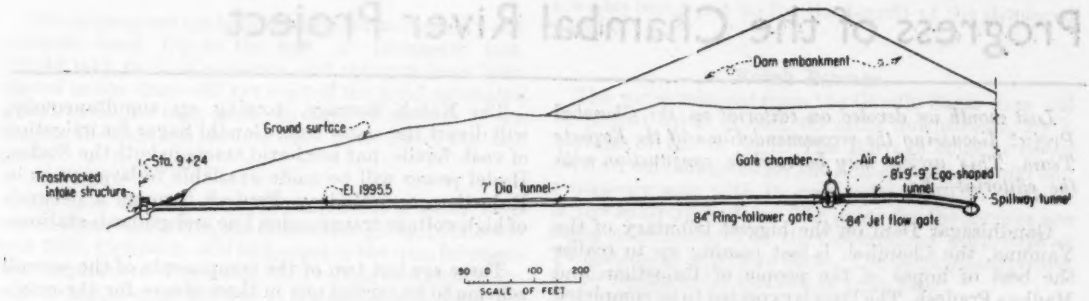
Profile on center line of spillway tunnel.



PROFILE ON ℄ SPILLWAY TUNNEL



PROFILE OF OUTLET WORKS



PROFILE OF AUXILIARY OUTLET WORKS

Profile of outlet works and profile of auxiliary outlet works.

the valves will be dissipated in a hydraulic jump-type stilling basin. Normal releases through the powerplant turbines when operating at the rated head of 375 feet will not exceed 3,700 cfs. Maximum releases through the turbines and outlet valves will be limited to 6,000 cfs.

Auxiliary Outlet Works

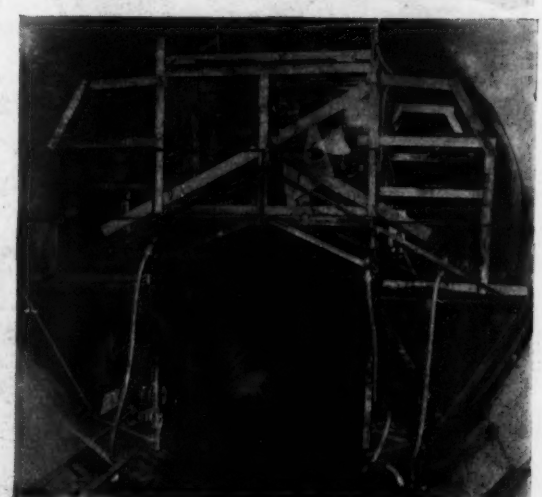
An auxiliary diversion and outlet tunnel has been provided to assure that riverflow diversion can be continued during the period when the main diversion tunnel is stoplogged off for installing the penstock system features. During operation of the reservoir, this outlet will also serve as an auxiliary or emergency outlet, in the event of a shutdown or breakdown of the main penstock system.

The outlet consists of a 7-foot diameter concrete lined tunnel, a trashracked intake structure, and 84-inch ring follower and jet flow control gates housed in a domed gate chamber. The tunnel is to be driven through the left abutment and is located so as to emerge into the lower leg of the spillway tunnel. The outlet will have sufficient bypass capacity to satisfy minimum transbasin diversion requirements when Trinity Powerplant and the main outlets are inoperative. No stilling of the high velocity flow at the intersection of the outlet and spillway tunnels is being provided, and because of the manner in which the two tunnels meet, flow down the spillway tunnel is expected to be rather rough and turbulent. During reservoir operation this outlet will therefore be used for emergencies only.

Personnel

W. A. Dexheimer, whose offices are in Washington, D.C., is Commissioner of the Bureau of Reclamation. Designs and technical supervision of construction are under the direction of Grant Bloodgood, Assistant Commissioner and Chief Engineer, in Denver, Colorado. The Trinity River Division of the Central Valley Project is in the Bureau's Region 2, of which B. P. Bellport is Director, Project Construction Engineer is L. B. Ackerman.

Pressure grouting of the outlet tunnel of Trinity Dam in progress.



[Continued on page 6

Progress of the Chambal River Project

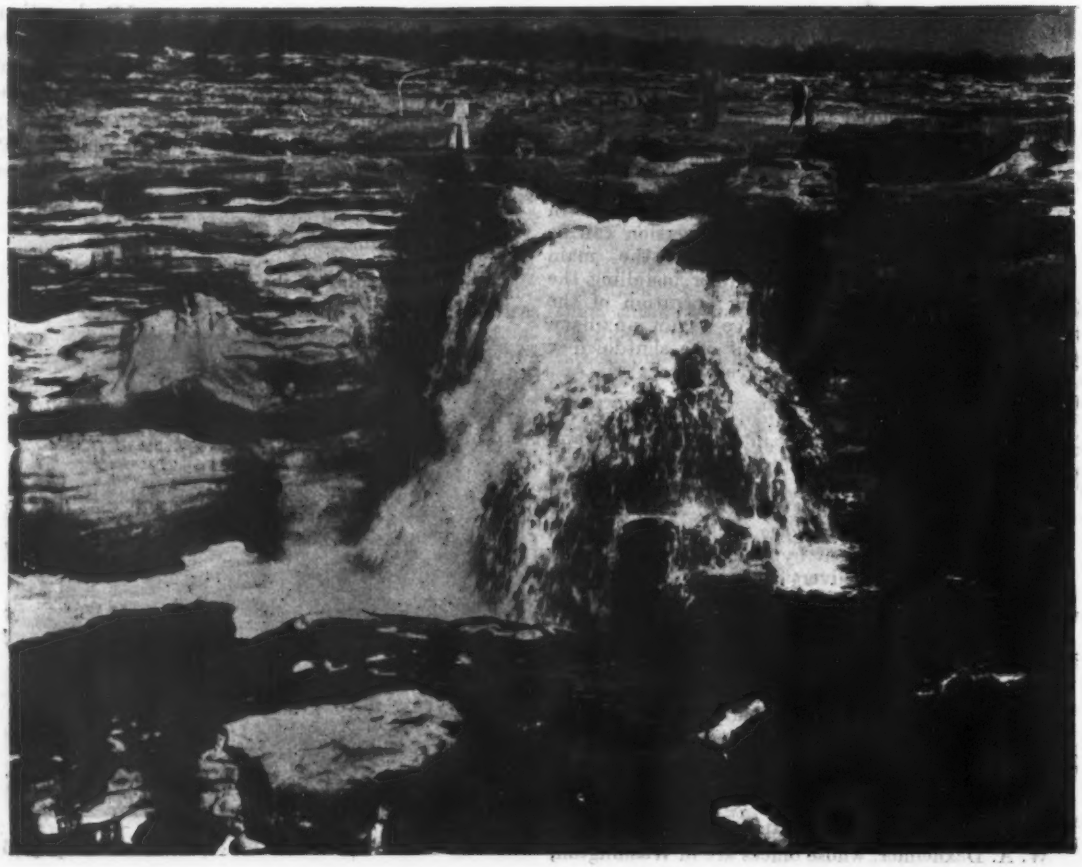
Last month we devoted an editorial on the Chambal Project discussing the recommendations of the Experts Team. This article may be read in conjunction with the editorial—Ed.

Gandhisagar Dam on the biggest tributary of the Yamuna, the Chambal. is fast coming up to realise the best of hopes of the people of Rajasthan and Madhya Pradesh. The Dam is expected to be completed in 1959.

The Kotah Barrage, coming up simultaneously, will divert the water from Gandhi Sagar for irrigation of vast, fertile, but semi-arid tracts in both the States. Hydel power will be made available to large areas in Rajasthan and Madhya Pradesh through a network of high voltage transmission line and grid sub-stations.

These are but two of the components of the overall scheme to be carried out in three stages for the maximum economic use of the Chambal flow. In the next

Chulia Falls on the Chambal River.



two stages two more dams—Ranapratap Sagar and Kotah—will be constructed between Gandhi Sagar and the Kotah Barrage, with two power stations and a further extension of the transmission system.

Gandhisagar Dam

The Gandhisagar dam will be a straight gravity dam, 1,685 ft. long and 204 ft. high. Started in 1954, it is being built in stone masonry with surkhi cement mortar. Twenty per cent of surkhi in the mortar saves that much of expensive cement. The use of stone masonry in place of concrete for the dam has resulted in a saving of about 15,000 tons of cement. Concrete is being used mostly in vulnerable places, such as the power house, spillway, and for capping the overflow section of the dam.

Steady progress has been maintained on masonry and concrete work. Up to the end of December last, 128·44 lakh cu ft of masonry and concrete have been placed in the dam—50 per cent of the total estimated quantity of 256 lakh cu ft In a major portion of its length, the dam has risen to over 75 ft. above the bed level.

The dam will impound 6.85 mil. ac. ft of water, with a waterspread of 266 sq.ml. Nine sluice gates, 10 ft. wide and 25 ft. high each, will be housed in the dam for reservoir regulation. Ten gates, 60 ft. long and 28 ft. high, will be installed at the top of the spillway portion for the discharge of surplus waters during flood time. A drainage gallery, 5 ft. wide and 7 ft. 6 in. high, situated 10 ft. above the foundation has been provided to collect any seepage water through the masonry. The small quantity of water that might seep into the dam from the reservoir will be conveyed to a sump well and pumped out to the river on the downstream side.

Construction Machinery

The concrete batching plant with three mixers of one cubic yard capacity each, and hauling equipment, such as locos and cableways, have been installed. Sand for mortar and concrete is not available at the dam site. It is being brought from the limited deposits at Chaurasigarh fort, five miles upstream. The sand shortage has also been met by crushing rock in the Rotary Sand Mill installed at the site.

Two cables stretch across the river at the dam site. Buckets filled with concrete from the batching plant are hauled by cableways. The concrete is then laid at any desired spot along the dam. The cableways thus help quick transport of construction materials and speedy laying of concrete.

Power House

The Gandhisagar Power House will be about 311 ft. long and 55 ft. wide. It will house four generating sets of 23,000 kW capacity. Power station works commenced on October 2,1957. Civil Engineering works for the trash racks—which are to sieve out timber and other debris from entering the turbines—head gates and penstock pipes, the outdoor switchyard for the installation of power transformers, high voltage switchgear and lightning arresters are in progress. The power plant is expected to go into commission by the end of next year.

The first stage of the Transmission System scheme envisages the construction of 911 miles of 132 kV and 66 kV transmission lines in Madhya Pradesh and Rajasthan to feed a number of grid substations.

Electricity transmitted from the station is expected to be delivered at 0.8 of an anna per unit at grid stations like Indore, Ujjain, Bhopal, Ratlam, Nagda, Mandsaur and Sheopur in Madhya Pradesh and Kotah, Jaipur, Ajmer, Sawai Madhopur and Udaipur in Rajasthan.

The Gandhi Sagar will submerge 165,000 acres in 228 villages, affecting about 50,000 people. Payment of cash compensation to displaced persons for lands and houses has been taken up, and completed in some cases. A few model villages with all essential amenities are also being put up for the benefit of the displaced people.

Kotah Barrage

The water released from the Gandhi Sagar dam will be picked up at Kotah, 60 miles downstream, by a barrage of 120 ft. high. The Barrage consists of an earthen embankment for the non-spillway section and a masonry weir with 19 crest gates of 40 ft. × 41 ft. in the spillway portion. The gates for the barrage are being manufactured in the Government workshops at Tungabhadra in Mysore State. The barrage is expected to be complete by the end of next year.

Two canals take off from this barrage. The right canal is the major one, with a discharge capacity of over 7,000 cusecs. The left canal carries a discharge of 1,500 cusecs.

The Right Main Canal, which is about 200 miles long will irrigate 12 lakh acres in Rajasthan and Madhya Pradesh.

The Canal crosses five major rivers by means of gigantic aqueducts. The recent proposal for a prestressed concrete syphon, aqueduct of 20 ft. diameter and 6,200 ft. long for this canal at the Kunu river crossing is probably the first of its type in the world. The work on the canal is in progress throughout its length, and 120 miles of the head reach is expected to be ready to supply water for irrigation by the end of next year. The rest of the canal will be ready two or three years later.

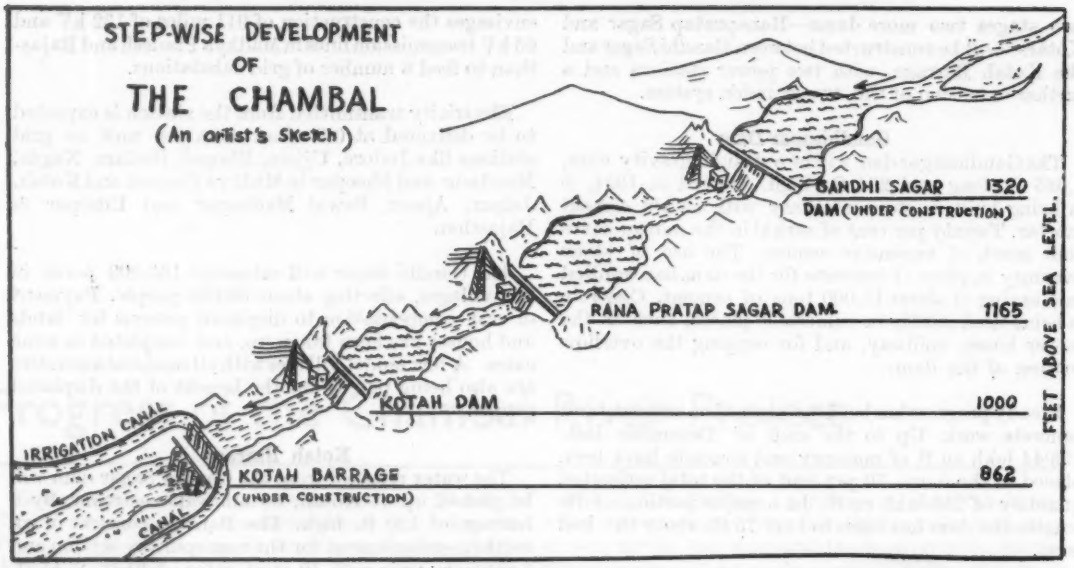
The left bank canal lies entirely in Rajsthan and is designed to irrigate about two lakh acres.

Costs and Benefits

The first stage of the project was originally estimated to cost Rs. 48.03 crores. The estimates have recently been revised and the cost is expected to be Rs. 63.59 crores. The completion of the first stage will result in 80,000 kW of power at 60 per cent load factor and 11 lakh acres of irrigation, half of which will be in Madhya Pradesh.

Labour Welfare

A large labour force, drawn from different parts of the country, is employed on the project. The labour strength at the dam and on canal is 30,000 during peak period and about 5,000 in the monsoon season. A Labour Welfare Officer looks after the interest of workers at Gandhi Sagar and the canals. Essential amenities such as labour sheds, free water supply, street light-



ing and medical aid are being made available to laourers. Qualified doctors are in charge of the project, hospital and dispensary. A mobile dispensary is serving the needs of the scattered labout in the canal area. Besides, the Gandhi Sagar Mazdoor and Karmachari Sangh is running welfare-centres for the workers. It organises social activities and runs a library and a gymnasium.

There are two Hindi schools. There is also a Tamil school for the benefit of the children of some 2,000 masonry workers from South India.

Holiday on the Chambal

The projects coming up on the Chambal hold out good promise of fine tourist resorts. When the Gandhi Sagar, with its expanse of water over 266 sq. mile is formed, arrangements for boating and fishing will be provided. The Chambal circuit house, overlooking the Sagar, will become an enchanting retreat. The foaming Chulia falls, about 30 miles downstream and within sight of the Ranapratap Sagar site, would be an idyllic spot for holiday-makers.

A hostel for accommodating technicians from abroad which is nearing completion on a hillock, just a mile from the Gandhisagar dam site will, after completion of the project, be thrown open to sightseers.

Salient Feature of Kotah Barrage

Location	Near Kotah City in Rajasthan across the Chambal, 60 miles downstream of Gandhi Sagar.
Barrage	
Type	Earth, masonry, concrete 120 ft.
Height	above the lowest bed level
Length	1,970 ft.
Canals	About 200 miles in the right bank and about 2 miles on the left
Benefits	
Irrigation	12 lakh acres
Cost	Rs. 34. 22
Progress	Started in November 1953, expected to be completed in 1962.

Salient Features of Gandhisagar Dam

Location	Across the Chambal on the borders of Madhya Pradesh and Rajasthan, about 30 miles from Jhalawar Road Railway Station.
Dam	
Type	Stone masonry
Height	204 ft.
Length	1,685 ft.
Quantity	25.6 mil. cu ft of masonry and concrete
Reservoir	
Storage	6.85. mil. cu ft
Waterspread	266 sq mil
Power Station:	4 Units of 23,000 kW each
Benefits	80,000 kW at 60 per cent load factor
Cost	Rs. 29.37 crores
Progress	Started in 1954. Expected to be completed in 1959.

Gauging Work: Its Significance and Progress with special reference to the Pre-Reorganisation Bombay State

(Continued from previous issue)

Part III

River Gauging:—

7.1 River Gauging: Objects: River gauges are established with the object of obtaining knowledge and data of

(*i*) the fluctuating water levels of the stream
(*ii*) the daily discharge passed
(*iii*) maximum discharge during floods
(*iv*) monthly discharges
(*v*) mean and total discharge during Kharif, Rabi and hot weather seasons.
(*vi*) Annual discharges
(*vii*) Stream velocity and silt contents during floods.
(*viii*) Estimate of safe and reliable quantity of floods available from the catchment for storage at a particular point and
(*ix*) Minimum flow conditions.

7.2.1 Nature of River Valleys in the Bombay State: Leaving aside the Konkan valleys which are small ones, there are eight main River-Valleys in the Bombay State. In the Konkan, there is considerable rainfall during the monsoon, but area cultivated in each valley being small, and number of valleys numerous, major schemes of irrigation to supplement rain are neither necessary nor feasible, and no gauging is therefore carried out there: although, in principle, it is essential to gauge all streams large or small, even in the Konkan.

7.3 Required Number of River Gauges: In the valley reports referred to in para 6.2.5, above, necessity of 166 new river gauges in addition to the then existing number of seventy-four (74) gauges, making a total of 240 river gauges for the Bombay State was proposed, the State having about 1900 miles of main-valley length with an average length of 235 miles per valley. This requirement is for eight (8) main streams and one hundred and ten (110) tributaries. Roughly, one gauge is required for every eight miles length of the main stream. Many river gauges have been established since 1950 in the State, and work of establishing the remaining ones, if taken up seriously on necessary funds being provided, can easily be completed within the next five years.

7.4 The following table gives details of tributaries and gauges proposed, valley-wise:—

Table No. 3

Srl. No.	Name of Valley	Length of main stream in miles.	Numbers of Tributaries of the valley		River Gauges proposed as per valley reports of 1950			Length in miles of main stream per gauge col. 3 & Col. 7	Average catchment Area in sq. miles served by each gauge
			Ordinary	Important	Existing	Proposed	Total		
1	2	3	4a	4b	5	6	7	8	9
1.	Sabarmati	200	7	6	10	18	28	9	A 139
2.	Mahi	253	12	4	5	23	28	9	A 143
3.	Narmada	150	11	4	1	25	26	6	A 146
4.	Tapi	295	12	4	10	19	29	10	C 447
5.	Godavari	140	6	10	17	14	31	5	B 232
6.	Bhima	350	3	12	11	28	39	9	C 435
7.	Krishna	345	8	12	13	33	46	7	C 435
8.	Tungabadra	100	3	2	7	6	13	8	B 217
	Total	1883	62	54	74	166	240	63/8=8	

7.4.1 Col. 8 shows that for every eight (8) miles of length of main stream one guage, on an average, is required. But details as per col. 9 suggest that one river guage on an average is required for the area of catchment varying from 139 to 447 sq. miles: the valleys of Group 'A' are broader near origin but narrower at the mouth: those in Group 'B' have part of their length on the border of the State and thus some catchment area on such banks is excluded: those of Group 'C' are again different in shape.

7.4.2 Main River Valleys in Bombay State

Table No. 4

Srl. No.	*Name of valley*	*Length of valley*		*Catchment area in sq. miles*	
		In Bombay state	*Total*	*In Bombay State*	*Total*
1.	Sabarmati	150	200	9360	9500
2.	Mahi	253	350	12988	17000
3.	Narmada	150	800	3766	36000
4.	Tapi	295	435	12617	-
5.	Godavari	140	900	7186	112,000
6.	Bhima	350	516	20980	-
7.	Krishna	345	800	17539	100,000
8.	Tungabhadra	100	400	2815	-

7.5.1 Basic considerations in providing and locating River Gauges: Requirement of River Gauges; their provision and location is proposed with the following consideration. At a site where there is a possibility of construction of:—

(*i*) A Storage work.
(*ii*) A Lift Irrigation Scheme.
(*iii*) A Hydro-electric project
(*iv*) A water supply scheme.
(*v*) A Bandhara for Rabi orHot Weather Irrigation.
(*vi*) A bridge for road.
(*vii*) where the streams touch or leave the boundaries of the Bombay State and another adjoining State, for ascertaining the runoff of the streams while they enter or leave the Bombay State.
(*viii*) Where the development of an existing irrigation project is contemplated and also
(*ix*) to measure the seepage and total quantity of water passing through the stream: On the tributary above its confluence with the main stream and on the main stream below the confluence for ascertaining the share of each tributary in the waters of the main stream.

7.5.2 Officers concerned and interested in the gauges concerned are consulted, before installing a new gauge.

7.5.3 Cost: If the scale as recommended by the Technical Committee for annually establishing river guages and rain guages were to be adopted, extra funds for maintenance also are required to be provided. It is not enough to construct new gauges but it is necessary to arrange for efficient maintenance of all those that are constructed. (Pl. vide Report no. 21. Srl. no. 5 in the Bibligography)

7.5.4. At these sites new rain gauges, if none exists already in the vicinity, are also to be established and the entire gauge station is also developed into a Climatological Station.

7.6.1 Sites for gauging-suitability of:—

The site is selected on taking into consideration the following points:

(*i*) It should be as near as possible to the proposed site of bridge, dam or weir.
(*ii*) The channel cross section should be uniform throughout the guage-run and uniform at all stages.
(*iii*) Its bed should be stable and so also the banks.
(*iv*) It should not be near the mouth of a river or a confluence lest back-water-effect comes in.
(*v*) There should be no bund or other obstruction in the bed or on the bank.
(*vi*) Banks should be straight and parrallel, without pockets of eddies or backwater, with no cuts or small streams entering in the length of the gauge run.
(*vii*) There should be a good natural central section.
(*viii*) Site should be easily accessible.
(*ix*) There should be no pool of water as the cross section area below zero gauge is considerable there.
(*x*) The bed should not be rocky and uneven or full of big boulders, lest taking accurate depth readings becomes impossible.
(*xi*) The stream should not flow eccentrically, particularly in the post monsoon and dry periods, in the case of large rivers.
(*xii*) A gauge run length of three times the river bed width or upto 1,000 feet should be available.
(*xiii*) River cross sections should be such as would allow zero of the guage being fixed conveniently.
(*xiv*) If possible the guage run should be so oriented and located that the direction of flow of current is neither along or against that of the wind for major period of the year.

7.6.2 In practice however, it is not always possible to satisfy all or even many of the above criteria, while fixing up a guage site.

7.7.1 Types and Categories of Gauges : Gauges are of the following categories, being classified according to the period of gauging :—

A. 12-monthly gauges (for perennial and big rivers)

B. 7-monthly monsoon gauges (from 1st June to 31st December every year.)

C. 5-monthly monsoon gauges (from 1st June to 31st October every year)

D. 5-monthly Hot Weather gauges (from 1st January to 31st May every year)

The category to be adopted depends upon the purpose of gauging and the nature of the river or stream to be gauged. There are very few tributaries in the Bombay State which flow all the year round, and ordinarily gauges of the category B or C are suitable. Category D suits where hot weather flow for Hot Weather Bandhara Projects, is to be ascertained while category C suits for gauging flow during Rabi

Season, as correct knowledge of cold weather flow available during November and December is very important for the success of a Rabi Bandhara Irrigation Scheme.

7.7.2 Types of gauges depending on method employed to find out discharge of streams.

I. River Gauge and Discharge sites : Area is computed on plotting cross sections on detailed survey and velocities are observed with float or a currentmeter. These are out of categories A, B and C above.

II. River Gauge or Stage Gauge : Only the gauge height is taken. Velocity measurements are not taken at the site. These are from Category 'C' above.

III. Channel Gauge: Only Chari or Channel measurements are taken by forming a channel of uniform section. These are of category D generally.

7.7.3 After Station rating curves are established a gauge from type I can be converted into a type II gauge.

7.8.1 Necessary Period of gauge observations : Some engineers are not in favour of continuing river gauging observations for eternity, but would rather discontinue the same as soon as (*i*) the project for which it was intended has materialised : or, (*ii*) the Station Rating Curve-Gauge-discharge-relation curve-has been established for which ordinarily observations for 20 to 30 years are necessary. No Hydrologist would readily agree to this. While the writer was investigating new dam sites in the Mutha Valley, it was found that nothing more than one solitary rain gauge at the Khadakwasla dam site was available : and that is why both the forecasting and the study of heavy floods of the type of the one received on 15-7-1954 by River Mutha becomes rather difficult and baffling.

7.9.1 Climatological Stations : For the Bombay State one climatological station for about 200 sq. miles of catchment area is required ; in addition a few stations have to be fixed also at key points such as the summits at the head of valleys.

7.9.2 Each Climatological station is equipped with the following within barbed wire compound on a plot of 20 ft. by 20 ft. at convenient locations :—

(*i*) Ordinary Rain-Gauge
(*ii*) Self-recording Rain Gauge (especially where annual precipitation is of the order of 100 inches or more)
(*iii*) Stevenson's Screen
(*iv*) Maximum and Minimum thermometers.
(*v*) Wet and Dry bulb thermometers.
(*vi*) Anemometers with or without wind vane.
(*vii*) Evaporimeters of various types—with 110° thermometer, viz :—
(*a*) Athavale type
(*b*) I.D.D. type
(*c*) Pitche type
and (*b*) Floating Pan type.

7.9.3 The River Gauge Karkun or Rain Gauge reader carries out the observations at the Climatological station, as well : and no separate staff is engaged.

7.10 Methods of Observation of velocity and their drawbacks.

7.10.1 With Surface Floats : Velocity is measured by noting the timing of surface floats passing over a known distance. The difficulties experienced with this method are :—

(*i*) Interference of surface winds or bottom obstructions to the float in motion.
(*ii*) The unsteady direction or path of the float.
(*iii*) The difficulty of finding out a suitable reach for a float travel and
(*iv*) The exact relation between the velocity of the float and the mean velocity of flow being not known accurately.

7.10.2 With Velocity Rods : More number of compartments will ensure the obtaining of average velocities near to the actuals but rods of different lengths are required and at times observations have to be repeated to avoid obstructions caused by weed growth or boulders. Wind influences the velocities of rods and the direction of motion is also affected and rods may not continue to travel centrally in the respective compartments, but may hang on to one side, thus giving wrong velocities.

7.10.3 This method, is not suitable for the big rivers, being very laborious.

7.10.4 By Current Meter : This method is superior to either of the two above mentioned methods, as (*i*) only one cross section is to be dealt with (*ii*) it gives quick results and (*iii*) there is less likelihood of error. But there are the following defects.

(*i*) Rating done by makers is spoiled by wear and tear. Rating facilities are not locally available, generally. (Central W&P. Station at Khadakwasla has provided the facility for calibrating current meters).
(*ii*) Inaccuracies creep in due to friction of moving parts viz. ball-bearings of fan and gear of the counter. Friction results in producing smaller number of revolutions and velocities work out less than the correct actuals.

7.10.5 For Channels with reasonably smooth bottoms shape of the vertical velocity curve being approximately parabolic, with the horizontal axis at the point of maximum velocity a short distance below the surface, the average of velocities at 0.2 depth and 0.8 depth is approximately the mean velocity. In Current meter measurement, velocity readings are taken at 0.2 and 0.8 of the depth and their average is the Mean Velocity.

7.10.6 Overhead cable and cradle arrangements are not always available. Boats are available only at a few stations and they get shifted downstream and the velocity reading gets vitiated and hence is not accurate.

7.10.7 Portable Standing Wave Flumes : In the hot weather season these are used with advantage for some rivers. They have to be re-fixed every day and care in fixing is required so as to avoid velocity of approach.

7.10.8 Stage-Gauge Discharge Relation : As daily current-meter measurements are time-consuming and

costly, Stage gauge can be utilised at comparatively small cost. A satisfactory record of stream flow can be obtained with a permanent gauge installation and the knowledge of the relationship between stage and discharge. The requirements for a fixed stage-discharge relation are (*i*) absence of backwater and (*ii*) a steady flow.

7.10.9 Recording gauge installations consisting of a stilling chamber with a clock-work instrument housed in a shelter are in use : one is fixed at Koregaon on the Bhima, in the Poona District ; and, same is giving good service.

7.11 Rating Curves : The stage (gauge) discharge relation at a gauging station is determined by measurements of discharge and observations of stage (gauge). The result of the measurements is plotted and a mean curve is drawn through the plotted points.

7.11.1 Reference is invited to Note No. 4 'Station Rating Curves' in which the S.R. curves for the (*i*) Mula river at Chas, a tributary of R. Godavari, and for (*ii*) Kukadi River at Pimpalwandi (*iii*) Mina River at Wadgaon (Shahani) and (*iv*) Ghod River at Kalamb, which are tributaries in the Bhima Valley are described and plotted (Vide S.N. 4 in the Bibliography—Annual Report No. 20 for 1953-54).

7.12.1 Staff : If and when funds for gauging work are inadequate, it is not possible to allow adequate salaries to be paid to the staff, and that does not attract capable persons to join or continue long. During floods the work is risky and tedious, gauges being away even from villages. With assured and adequate funds proper type of persons can be recruited and provided with essential training of gauging work, and old staff can be coached with refresher courses. That will secure better quality of work and ensure collection of reliable data.

7.12.2 Following equipment and facilities are necessary to be provided for the gauging staff :—

(*i*) A hut at the site with a cabin for office and records.
(*ii*) Umbrella and Kambals once every two years and a pair of swimming shorts every year.
(*iii*) Life-buoys and floating platform.
(*iv*) Boats : small tonies for small rivers and large boat s with sails for large rivers. Power launches for bigger rivers like Tapi with khalasies, boatmen and accessories.
(*v*) Current meters and other measuring apparatus including stop-watches
(*iv*) Automatic level recorder for important stations
(*vii*) Cable and Cradle arragements with winch at gauge stations on torrential streams in hilly areas and
(*viii*) A medicine chest : Water-proof bags and water bottles.

7.13 Duties of a Gauge Reader (River Gauge Karkun)

1. To take velocity measurements and gauge readings in the morning and in the evening ; during the monsoon, measurements are to be taken more often as the flood level changes.
2. To inspect Gauge posts and guide posts at every visit and to report damage if any.
3. To prepare A and B forms, calculate the velocities of the compartments and mean velocity of a section, (H.M.D.) Hydraulic mean depth, 'C', and discharge, and to enter the same in the statements.
4. To prepare Charies (Channels) in the hot weather period and take measurements of discharges.
5. To keep the gauge run cleared of vegetation, bushes thorns etc.
6. To maintain the inward, outward and stamp registers and other forms (14 nos. in all) and to submit indents for the materials required.
7. To take readings and observations pertaining the maximum and minimum thermometers, dry and wet bulb thermometers, evaporimeters, animometers rainfall etc.
8. To submit '10-days' periodical reports of velocity and discharges observed and the rainfall and climatological report of the same sub-period (of 10 days)
9. To submit monthly discharge statements with necessary abstracts of climatological and rainfall reports and prepare three copies of each.
10. To maintain labour muster-rolls and carry out repairs to gauge and guide posts plates, raingauges and carry out painting or coal-tarring for these and comply with orders of his superiors.
11. To erect new rain and river gauges as per estimates and orders and engage necessary labour on muster-roll.
12. To collect information regarding lifts from wells by mot's engines etc. as may be required.
13. To explain the gauging work to visitors and train newly employed recruits.
14. To inspect and take measurements of flow at sites on other streams, in the neighbourhood as required.
15. To collect silt samples at every flood during monsoon, and on the 1st, or other required date, in the hot weather, also, of neighbouring tanks and send the samples to Head Office.
16. To obtain information of rainfall of other organisations nearby and submit the same.
17. To clean and dry up the current meter and other instruments daily, and take care of batteries.
18. To get the boats towed to place of anchorage, anchor them properly, remove gauging implements and remove leakage if any. To carry out all necessary repairs after monsoon and repaint the load- line.

Part IV

Conclusion and Acknowledgements

8.1.1 Rainfall—Runoff—Relationship: The Relationship between Runoff and Precipitation can aptly be expressed, in the writer's opinion, by a formulae of the following pattern:—

$$R = mP - E$$

and, this equation can be elaborated into one, of the following type:—

$$R = m.P.c.A^{n} - E$$

where,

R is the Runoff : appropriate units to be adopted;
P is the total Precipitation (of a Storm).

m is a coefficient to be obtained after observation of actual Rainfall and consequent Runoff, and on appropriate analysis of a number of cases of typical maximum-intensity-Storms of varying durations, over the catchment. 'm' will depend on the nature, extent, intensity and duration of the storm and quantity of the Precipitation.

'A' is the Area of the particular catchment concerned. It is well-known that catchments have their individual characteristics and differ in various respects, such as:—

(*i*) Geological formation, including the soil-mantle, subsoil, sub-strata and depth and nature of rock. Percolation and Ground-Water conditions would greatly depend on these.

(*ii*) Physical features of the terrain such as steep, moderate or flat slopes; presence of hills and hillocks, plains and vales, and so on.

(*iii*) Nature and condition of land surface whether it is comprised wholly or partly, of forest, grassy lands, pastures, cultivations, deep or shallow-ploughed fields, garden lands or barren waste, or sandy or desert lands. Percolation and phenomena of Ground-Water conditions will be affected by these factors—which also consequently affect the Runoff.

(*iv*) Distance from Sea or Ocean-Coasts.

(*v*) Orientation of the Major Axis of the Catchment with reference to the direction of the prevailing Monsoon Winds.

(*vi*) Shape of the Catchment.

(*vii*) Extensiveness and total Area of Catchment.

(*viii*) Geographical Location of the Catchment regarding the Climatic Region.

(*ix*) Area of Rainfall Activity upto the line or point of the Valley under consideration, for Runoff, Storage and Surplussing or Waste-Weir arrangements.

Values of the Coefficient 'c' and index 'n' would depend on these factors.

'E' denotes the losses which comprise mainly of Evaporation and Transpiration and are essentially a function of average annual Temperature obtaining over the Catchment, so long as there is enough rainfall to satisfy evaporation.

Thus R will ultimately, be the final result depending upon P and A—the Catchment Area—and on their Coefficients 'm' and 'c' and the index 'n'; and also on Temperature of the entire tract as it governs E, the losses—the two main types of losses coming under E, being the Evaporation and Transpiration losses taking place over the Catchment.

8.1.2 It is neither the purpose and objective of this paper, nor is it possible here to work out the actual values for the above mentioned Co-efficients and Index; as, determining of same must depend on detailed study and analysis of Precipitation and Catchments, Runoff, Temperatures, Humidity, Wind, and actual Evaporation and Transpiration Losses, all being continuously and systematically observed for a sufficient number of years for particular Catchments. Then, results for neighbouring and similar Catchments, as well, can be evolved, with necessary data available.

8.2 The following Formulae appropriately take into account the effect of temperature for computing the runoff :—

1. *Vermeule's formula :*

$$R = P - (11 + 0{\cdot}29P)\,(0{\cdot}035\,T - 0{\cdot}65)$$

where R = Annual Runoff.
P = Annual Precipitation
and T = Mean Annual temperature.
and 2. *Khosla's Formula :*

$$R_A = \Sigma R_m$$

$$R_m = P_m - L_m$$

$$L_m = \frac{T_m - 32}{9.5} \quad \text{where } T_m > 40°F.$$

With this formula a rough forecast of water yields of various catchments in India was made and it was estimated that all the rivers of India pour out annually into the seas about 1356 mill. a.ft. of water, the average annual Rainfall over India being 42 inches : and allowance for snowfall and snow melting being made for the Himalayan Rivers ; while, all the rivers of the earth return to the Oceans about 7,000 cubic miles of water (or about 20% of the Annual Precipitation) according to Hydrologists.

8.3 Acknowledgements : The writer wishes to express his thanks to Shri M.L. Champhekar, M.I.E.I.S. E(Retd) Chief Engineer P.W.D. and Koyna for his encouragement and keen interest and to Shri A. G. Maydeo, M.I.E., B.S.E.(I) Superintending Engineer P.W.D., Sri R. F. Boga, I.A.S., and Prof. S. R. Bhagwat, L.C.E. for their keen interest. The author is grateful to Shri V. T. Mandke, now Executive Engineer, and Shriyuts R. R. Galgalli, S. D. Kulkarni and B. R. Pansare, Deputy Engineers for their valuable assistance while inspecting and investigating sites for tanks and storage reservoirs in the Ahmednagar, Poona, North Satara and Sholapur Districts, respectively, and to Dr. D. G. Kulkarni, Soil Physicist, and Shri D. B. Dongre, Deputy Engineer, for their valuable assistance in collecting and checking data used in this paper and work pertaining to Climatological Stations, River gauging, and Rain Gauges, while in the Irrigation Development Division, Poona.

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Progress of Electrification in French Africa

The amelioration of living standards and economic effort in the overseas territories is very closely linked to the potential sources of abundant and cheap power. Coal is scarce in Africa, and until recent discoveries were made, oil resources were almost non-existent. Unquestionably, electric energy is destined to be the main source of this power.

In French Africa, thermal electric power is essentially the answer, produced from imported coal or liquid fuels. Even in view of the increased imports of fuel as a result of the spectacular rise in transport activity, the record of these imports over the years is a significant one.

Imports of Petroleum Products
(*in* 1,000 *tons*)

	1938	1948	1956
French West Africa..	51.4	111.1	437
Togoland	2.7	3.7	14.8
Cameroons	7.8	27	87.3
French Equatorial Africa	13.2	32.6	118.1
Madagascar	18.7	30.6	117.8
Total	93.8	205	775

Hydraulic Resources in Africa

Of all the continents, Africa is the one with the greatest potential in hydraulic electric power. A few figures will illustrate this. The world's hydroelectric resources are estimated at more than 500 million kW, of which 200,000,000 are found Africa. Whereas 4/5 of European and ¼ of North American resources are already being exploited, only a very small fraction of the African potential has been touched, despite recent efforts in this direction. It is not surprising, therefore, that the first equipment plan of the French overseas territories concentrated heavily on taking stock of hydroelectric resources. Africa's tremendous potential explains the vast industrial projects being carried out, and for which electricity is an essential raw material.

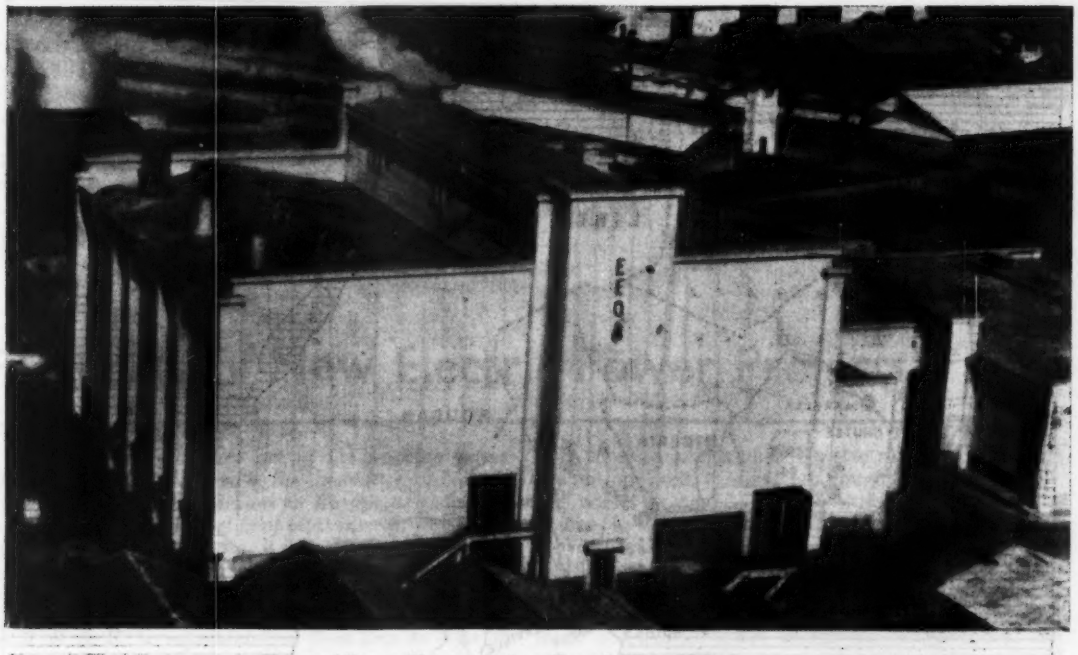
This list of natural resources was quickly complemented by careful study of certain basic improvements projects: Edea in the Cameroons, Djoué and Bouenza in the Middle Congo, Bouali in Ubangi, and several other sites in Madagascar. For this reason, public investments for greater production in the first plan (1947-1953) saw a large part of the funds earmarked for electricity: 4.8 billion francs in French West Africa (20% of the budget); 1.5 billion in French Equatorial Africa (25% of the total allotment) and 2.2 billion in the Cameroons (60% of the budget).

The first plan also reserved an important place for the electrification of native communities, in order to propagate better lighting and artisan activity.

The two-fold French effort brought about amazing results during the first plan:

	Installed Capacity in kW		*Production in millions kWH*	
	1946	1952	1946	1952
Franch West Africa	7,200	30,000	18.6	60
Togoland	640	1,250	1	1.7
Cameroons	530	5,400	0.9	13
Franch Equatorial Africa	2,550	13,950	4.1	22
Djibuti	530	3,000	0.7	2
Madagascar	11,800	20,500	19.3	52
Totals	23,250	74,100	44.6	150.7

Thus, in five years installed capacity had nearly tripled, while production more than tripled. Most of this was the result of thermal equipment. At the end of this first plan, several hydroelectric equimpment projects were under way: the Great Falls on the Samou river in Guinea, with a 9,000 kW power and an average annual production of 57 million kWH; the Edea dam on the Sanaga river in the Cameroons capacity 20,000 kW, production 160 million kWH ; Bouali on the M'Bali in French Equatorial Africa—capacity



Thermal Power Plant at Dakar (French West Africa)

3,000, kW, production 26 million kWH ; Brazzaville on the Djoué (Congo tributary)—capacity 15,000 kW, production 132 million kWH: all in all, a 47,000 kW capacity and a forthcoming production of 375 million kWH.

A large part of the funds relegated to the second equipment plan (1953-1957) was also reserved for hydroelectric installations: 10.6 billion francs in French West Africa; 800,000,000 in French Equatorial Africa; 900,000,000 in the Cameroons.

Rise in Production

Although pursuing more limited objectives, the second plan nonetheless saw an equally spectacular production development. In 1953, the three major

Hydro Electric Installations near Boali (French Equatorial Africa)

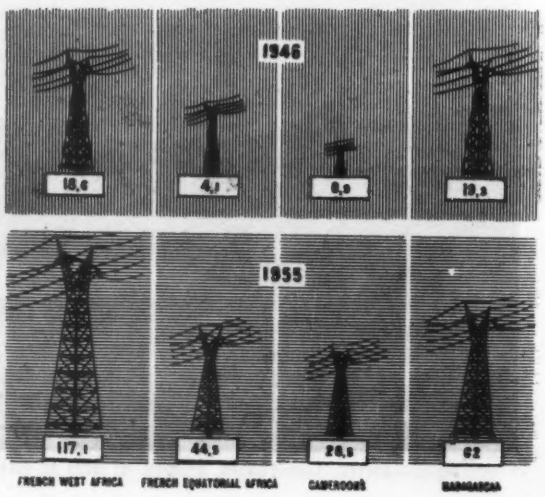
● - Already built ◑ - Being built ○ - Being planned ■ - Main thermal power plant

power plants at Great Falls, Edea and Djoué were inaugurated. Bouali went into operation in 1955, and Mandraka, near Tananrive, in 1956. By the end of 1955, total production reached 117.1 million kWh in French West Africa, 2.32 million in Togoland, 28.5 in the Cameroons, 44.5 in French Equatorial Africa, 62 in Madagascar, 5.06 in Djibuti, for a total of 260 million kWh as compared to 150 million in 1952.

Several trends are evident in the French electrification policy in the overseas territories. Aside from the social aspect, designed to bring electric power within the reach of everyone, there is the trend towards industrial development of the large communities; thus, industrialization and higher living standards appear closely linked together. During the past few years, a third trend has taken its place alongside the first two: the creation of large plants of several billion kWH, capable of feeding the heavy-consumer electrical industries. Three major projects are associated with this trend: the extension of the Edea plant to increase capacity

Continued on page 36

Electric Production—(Millions of kWh)



Financing of New Electric Power Projects

These are two chapters out of the working paper dated May 6,1958 prepared by the Committee on Electric Power, Economic Commission for Europe, as a basis for discussion. As the subject is of vital interest for under-developed countries in Asia, it is published here for the benefit of our readers. Mention may in this context be made of the prolonged discussion about the rate of profit to be allowed to the Electricity Industry in India and the F. E. S. U.'s. representation from time to time to the Government of India—Editor.

The economic development of a country being directly linked with increased consumption of power, the electricity-producing industry must anticipate economic and social expansion by constructing the appropriate means of production for meeting future requirements. Lack of financial resources must not be allowed to check this expansion for fear of a subsequent economic crisis.

An examination will be made below of the various resources available to countries for long-term investment, the possibilities of their increase and their advantages and disadvantages. They are five in number.

- State subsidies and loans
- issue of shares
- self-financing
- issue of public loans
- loans contracted in foreign countries.

In general, simultaneous use is made of most of these means, but for the purposes of analysis they will be examined separately. Among them subsidies only do not affect the financial charges of the undertaking. At a period of restriction in the financial market, the charges deriving from the other four resources may lead to increased costs, which cannot be entirely offset either by the improved outpur from the equipment as a result of technical progress or by a reduction in specific administrative and supply costs owing to increased sales of power. Increased rates, therefore, would be called for, but this often meets with a certain number of difficulties.

State Subsidies and Loans

In order to develop the economy of certain non-electrified regions, the State may assist electricity undertakings by subsidies to provide for the non-economic investments that are required.

In those countries where the electricity undertakings are nationalized, it might be thought that their financing could be carried on the State budget. Such a course, however, would lead to competition with other services, such as education, roads, etc. and there would be, first, the risk that the new equipment programme would be dependent on budgetary availabilities instead of being determined solely by trends in the development of electric power requirements. Secondly, the subsidies might be used in order to keep the price of electricity at a low level, with a resultant stimulus to the consumption of power which would lead to a disproportionate growth of requirments and thus to further investment. Lastly, the deficit caused by the excessively low rate would have to be offset from public financial resources.

Issue of Shares

The issue of shares in order to increase the undertaking's real capital may be considered only if the existing regulations enable the enterprise to make a sufficient profit.

Usually dividends are higher than the interest on loans. On the other hand, their flexibility as compared with the fixed interest on loans allows their adaptation to the overall profit-making capacity of the capital. However, whether nationalized or not, in the interests of the economic and social situation of the country the electricity undertakings are under the obligation to supply electric power at the lowest rates. There is therefore a conflict of interests between the electric power producer and the shareholder, who seeks to improve the return from his savings. Municipalities, departments, provinces or the State itself are usually the principal shareholders in electricity undertakings, but their inability to meet the increasing demand for fresh capital has encouraged undertakings to consider the issue of shares in order to attract private savings. With this end in view, proposals have been made for:

- the public issue of shares of low nominal value;
- the simultaneous joint issue of debentures and shares;
- the issue of short-term debentures, convertible into shares;
- the issue of preference shares without voting rights (this really amounts to a non-repayable) loan);

- issue of shares or debentures whose purchase would be compulsory by industry, handicrafts or other large consumers.

Self-financing

Usually, part of the funds necessary for new investment be provided by the electricity undertakings themselves by using the reserves represented by depreciation or by setting aside part of the profit balance.

The proportion of investments covered by self-financing varies appreciably between countries on account of differences in the financial management of the undertakings, which is often under State control. According to information published by the OEEC, the percentage figures for 1951 were:

- 15.1 in France
- 87.3 in Belgium
- 17.0 in Italy
- 39.1 in Switzerland and
- 42.0 in the United Kingdom (CEA)

A frequent criticism of self-financing is that electricity undertakings, in view of the importance of electricity production in the economic and social field, should not be allowed to make profits in excess of a reasonable profit-making capacity of the capital invested. Any higher profits, even though used for new investment, would imply the sale of electricity below its economic price. According to the same argument, electricity undertakings should limit equipment depreciation to a reasonable percentage of its original cost, refraining from any secret reserves to be used for new investments.

A contrary view is held that, unless equipment depreciation is calculated on the basis of replacement value and if no profits are made, sales receipts would no longer cover real operating costs.

Assuming that there is no variation in the equipment costs over a period exceeding the lifetime of the equipment, say twenty years, the equipment depreciation will be 5 per cent of its replacement value. Assuming further that the undertaking has to invest each year 12.5 per cent of the replacement value of its equipment, i.e. 5 per cent for the replacement of out-of-date equipment and 7.5 per cent to meet increased consumption, the equipment depreciation would then cover 40 per cent of new investment.

So long as the market can provide the balance required for investments because of a low rate of interest, financing by increasing capital and by public loans seems preferable to further self-financing However, at a time when market restrictions are pushing the interest rate up to 7 per cent or if it is necessary to attract foreign capital, an extension of self-financing by the provision of a profit balance derived from increased revenue seems to be required.

Take the case of a private electricity company operating with its original share capital, which finances the whole of its new equipment out of its own resources. Assuming, further, that each year 5 per cent of the plant has to be replaced by new equipment and that the increased demand for power requires an expansion of equipment of 7.5 per cent and, lastly, that the dividend rate of the initial capital is equal to the rate of interest that the company would have to pay for loans repayable in twenty years, it can be shown that the sums drawn from the trading profits by the company in the twenty-first year of operation would be equal to the financial charges that it would have to bear during the same year if all the investments were financed by loans bearing interest at 8.65 per cent. In the thirty-first year, equality of financial charges would be achieved for an interest rate of 7.5 per cent.

Issue of public loans

The issue of fixed-interest long-term public loans has always been a valuable source for financing new investment in electricity undertakings. In periods when interest rates are low, public loans have provided a large volume of cheap capital, but increased demand for capital in the market rapidly raises the interest rate necessary for the success of such an issue. In that case, however, the redemption period of such loans may be limited in order to replace them as soon as market conditions improve by others at a lower rate of interest and with longer redemption periods.

Loans contracted in foreign countries

Where the possibilities of the home financial market are limited, attempts are sometimes made to raise capital by loans obtained from international banking institutions or floated on the market of another country where the shortage of capital is less pronounced. Although in this way the required capital can be raised at a lower rate of interest, such loans have the drawback that both interest and repayment have to be paid in foreign currency. In principle, therefore, they are justified only for investment which, through the export of electric power, for example, ensure for the country a holding in foreign currency.

Moreover, the trends in the different European financial markets are very similar, and the raising of capital in other countries cannot therefore provide a satisfactory long-term solution to the problem of the financing of investment.

In conclusion, the continued financial soundness of electricity undertakings inevitably calls for great care in the choice of the sources to be drawan upon for financing new investments. It seems justifiable to use the profit balance for an appreciable part of the capital required by a sound policy of depreciation made annually in the book value of existing equipment. For the remainder, the best means are public loans and increased share capital, although the latter may have certain fiscal drawbacks. State subsidies are very useful for non-economical investment made with the sole aim of developing electrification. State assistance in financing investments required for the normal expansion of the undertaking by means of subsidies and reduced-interest loans with a view to keeping the price of electricity below its economic level, however, runs the risk of non-economic operation and an exaggerated demand for electric power. Loans in foreign countries may sometimes be considered for investment which would open up new sources of foreign currency. When used for constructing plants to meet the internal needs of the country, they are also accompanied by certain risks to the future financial position of the undertaking. In such cases, it would be better to contemplate increased self-financing, even though the result were

to be an increase in the price of electricity. In fact, self-financing ensures a sound financial situation for the undertaking, a necessary condition in the natural evolution of the electricity-producing industry, which is one of the bases of the economic develpment of a country.

Rate-Fixing of Electric Power

Basic principles

The sound operation of an electricity undertaking assumes, first, that rate-fixing will ensure that receipts will cover all operating costs and guarantee a reasonable profit on the capital invested. It is only fair that all consumers using the net work's power under the same conditions of voltage, capacity and load should pay the same price.

The operating costs of an undertaking may be divided into two categories: fixed costs, which are independent of the amount of power produced and sold, such as those represented by the capital invested and maintenance of equipment and administration, and variable costs, which depend on the amount of power produced, such as, in the case of thermal plants, the cost of fuel consumed.

Whereas it is comparatively easy to calculate the variable proportion of the cost of electricity under given conditions of consumption, this is not so as regards the fixed part. There is, admittedly, a certain relationship between the fixed part of the cost and of demand and the utilization factor of the demand, but no accurate method of determining it is known. Certain rate experts, it is true, claim that the application of the economic theory of marginal price gives a fair distribution of fixed costs among the different categories of consumer. The opponents of this theory, however, maintain that it applies only in conditions of perfect competition, which are never found in the case of electric power supply. Moreover, the marginal theory does not ensure that receipts will offset all the operating costs, and rates fixed on the basis of that principle make use of a weighting factor called "toll".

Occasionally, in order to improve the weighting factor of the equipment, undertakings endeavour to attract special consumers who are ready to consume large quantities of power during slack periods for particular uses, such as electro-thermal applications. In such a case, in order to increase profits it is merely necessary to sell the power at a price higher than the variable part of the cost, and the price of other competing power agents is then taken as a basis for the determination of the sale price.

Sometimes undertakings, using a demand utilization factor of almost 1 have granted large power consumers (electro-chemical industries) a rate slightly higher than the average cost of the power produced by plants specially constructed for that purpose. Nevertheless, it would be impossible for them to supply larger quantities at the same price, since the average cost of power produced by new plants would be higher.

The foregoing considerations explain the variation in electricity prices, which are conditioned by the different characteristics of consumption and by the action of certain undertakings for the purpose of attracting new consumers.

Problem of readjustment of selling price

The continual fluctuation in building costs, wages, the interest rates on loans, together with the cost of fuel consumed by power stations, calls for occasional readjustment of selling prices in order to ensure the budgetary stability of electricity undertakings.

The consumer, however, must have the guarantee of a certain stability of rates in order that capital invested for the use of electric power for his own requirements may show a profit.

In a certain number of countries, the public authorities have reserved the right to approve electricity rates, which constitutes a protection for the consumer against too frequent changes in price. Moreover, in other countries where the price is not subject to State authorization electricity undertakings are under a moral obligation not to increase their rates too frequently. State intervention in rate-fixing often has the effect of protecting certain categories of consumers for economic and political reasons.

Large quantities of power are often supplied at a rate composed of a fixed charge and a price per unit consumed. In order to increase their turnover, undertakings have frequently granted low unit rates and the resultant increased consumption brings about a fairly rapid fall in average receipts per kWh for such a group of consumers. The consequence is that average receipts per kWh fall below the real cost and the problem of rate readjustment then arises.

Generally speaking, the readjustment of special rates granted by the undertaking in order to improve the utilization factor of its equipment creates the most difficult problems. In this case, an increase may nullify profit-making capacity of the equipment installed by consumers in order to benefit by the lower rate and in extreme cases may result in the liquidation of whole industry.

These are usually cases of the supply of very large quantities of power. In Austria, for example, the consumption of the iron and steel and non-ferrous metals industry, which enjoys very low rates, represents approximately 40 per cent of industrial consumption or about 25 per cent of the total consumption of electric power. Unless these low rates are raised, the only means of obtaining budgetary equilibrium would be by a disproportionate increase in other rates. Moreover, consumption enjoying low prices tends to rise, which compels undertakings to raise new capital in order to meet the increasing non-economic demand. However, national economy needs may require the survival of an industry whose existence depends on the consumption of cheap electric power. However that may be, if, for various reasons, rates cannot be increased for certain uses, even though the power is sold below its real cost, it seems necessary to check the growth of such uses by accepting new consumers of the same kind only subject to their agreeing to suitable rates.

Lastly, a readjustment of prices can be applied only after a certain delay, particularly if there has to be a preliminary study of the financial situation of the electricity undertaking by a control commission. In order to eliminate that delay, certain countries, such as Belgium and France, have adopted a system of

automatic readjustment of electricity rates under which the price of electricity is based on an economic index, determined monthly, depending on fluctuations in the prices of coal and wages and the cost-of-living index.

Effect of an increase in rates

Although for some electro-thermal and electro-chemical consumers an increase in the price of electricity supplied by the networks may seriously affect their budgetary equilibrium, this is not the case for the other consumers of electric power. Since the end of the second world war, electricity prices have increased in all European countries, but, the movement of the price of electricity index is appreciably smaller than that of the cost-of-living index, so that in comparison with the immediate post-war situation, electricity is relatively cheap. It would seem, therefore, that an increase in electricity rates would be possible if the increased cost of building materials, wages and fuel could no longer be offset by an improved organization of construction work, higher administrative and supply efficiency and a greater output from the equipment.

The economic and social repercussions of an increase in electricity rates often seem to be exaggerated and in this connexion a study made in Austria is significant. The subject was the increased total costs of different categories of consumer which would result from a general 25 per cent increase in electricity prices, and the results are given below:

Increase in total costs of consumers resulting from a 25 per cent increase in electricity prices in Austria

	(%)
Private consumers (domestic consumption)	0.3
Agriculture	0.3
Industry (average)	0.6
Iron and steel	1
Paper-making industry	1
Fertilizer industry (nitrates)	2
Electro-chemical industry	4.4

Generally speaking, these increases seem bearable, except perhaps in the case of the electro-chemical industry. If the increase in total costs of the fertilizer industry were borne by the domestic consumers of its products, agricultural cost would rise by 0.03 per cent.

With regard to the electro-chemical industry, an increase in costs of 4.4 per cent would perhaps not be practicable, although in Austria a 25 per cent increase in electricity prices is regarded as necessary in order to preserve the profit-making capacity of the electricity undertakings. However, if in such a case the liquidation of an industry which can no longer pay the cost of the power that it consumes were to have unwelcome economic and social consequences, it would be better for the State to come to its assistance by subsidies, instead of compelling the undertakings to continue supplying power at a price that no longer covers their costs. Such a solution would give a better indication of the industry's real economic situation without endangering that of the electricity-producing industry.

International Commission on Irrigation & Drainage

Set up in 1950 with headquarters in India to stimulate and promote the development and practice of irrigation, drainage and flood control, the International Commission on Irrigation and Drainage held the first Congress in New Delhi in 1951. The Second and Third Congresses were held in 1954 and 1957 in Algiers and San Francisco respectively. An annual meeting of the International Executive Council of the Commission was held recently in Rome, preceded and followed by study tours to irrigation and drainage works in Italy. In addition to other official business of the Commission, the Council took a decision on the subjects to be discussed at the Fourth Congress of the Commission to be held in Madrid in 1960. The subjects selected are : (1) Reclamation of waterlogged and marshy lands, (2) Sprinkler irrigation, (3) Tolerance of plants to minerals in solution in irrigation water and soil and (4) Use of longitudinal embankments or levees as floods protection measures.

After the meeting, His Holiness the Pope of the Vatican City graciously received the members in his palace and appreciated the work being done by the Commission. His Holiness delivered the following message on the occasion :

"We are happy, gentlemen, to have been able to grant your request to be received this morning and to say a work of encouragement for the contribution your Commission makes to the welfare of your fellowmen.

The words IRRIGATION AND DRAINAGE may strike a very material and prosaic note ; and yet they spell out a human aid to the fruitfulness of nature, on which depend more or less the health of vast sections of society as well as their social and consequent moral betterment. The very international character of your Commission bears witness to the world-wide need of the complex engineering projects you are developing and trying to make more perfect.

The art of irrigation and its absolutely necessary concomitant, drainage, has come a long way across the thousands of years since man first began to harness certain forces of this earth and guide them to an increased and more dependable productivity according to the character of the soil and the demands of a planned agriculture. The natural riches lavishly prepared by God for the creature of His infinite Love have been made more useful for more men, human misery has been relieved and means provided for the improvement of family and civic life. So far-reaching are the results of the work for which your Commission speaks. May God prosper it ! And may His blessings also enrich your own lives and the lives of those who are near the dear to you."

Kashmir Session of the Central Board of Irrigation and Power

By BALESHWAR NATH

Where nature is bountiful with water and where water rolls down tne steep gradients almost throughout the year, Irrigation and Power engineers see ample raw material to shape it into the finished product of its utilisation for irrigation and power purposes. Such is the inviting setting of Kashmir valley; and added to it is its natural beauty, its congenial summer climate and its exquisite mobile house-boat life, over the sparkling water of the river and the lakes. The Central Board of Irrigation and Power had held its annual Research Session in that unique setting, for the first time, in 1955. In the following year, it accepted the invitation from Ceylon Government and went all the way south to hold its 1956 session in Colombo. Mysore was the venue for 1957 session. But the call of Kashmir was ever ringing in the ears of its members. A return to the enchanting valley, within a period of only three years, though betokening partiality was eventually a welcome fixture to all concerned. The 28th Annual Research Session of the Central Board of Irrigation and Power was accordingly, held in Srinagar during June 1958 and attended by a large number of delegates from all the States of India, some foreign specialists any by representatives of many Research Institutions, Universities and International Organisations. The session was followed by a Seminar organised by the Ministry of Irrigation and Power, in which participated many a Minister from different States of India, financial experts and officers from various other Ministeries and Departments.

Universal Hospitality

The venue of the Conference was the newly built Tourist Reception Centre at Srinagar. This spacious block of buildings is an unique institution. It is centrally located, and, is in fact, situated under the very shadow of the renowned Shankaracharya temple. Under its roof are located all such amenities that a visitor or tourist might seek to make his visit interesting and convenient. There are Air Line Offices Post and Telegraph Offices, Roadways and bus terminus and all other concerned departments grouped at this Centre. Two large Conference rooms on the first floor provide ample space for big conferences and parties. Retiring rooms and cafeteria attached to this Tourist Centre afford great convenience to the persons arriving at Srinagar after long and tedious journeys. In short the Tourist Receiption Centre at Srinagar presents an integrated approach on the part of Jammu and Kashmir Government, towards universal hospitality and is, indeed, a project of commendable value, not found elsewhere, atleast in the eastern hemisphere.

Bakshi Ghulam Mohammad, Prime Minister of Jammu and Kashmir State, in a short and stirring speech, welcomed the delegates to the beautiful Jhelum valley and expressed the hope that deliberations of the Conference would have great bearing on the execution of the river valley projects in progress in the country. He particularly stessed upon the need of collaboration between the engineers of Jammu and Kashmir State and those of other States in India.

The Session was inaugurated by Hafiz Mohammad Ibrahim, Union Minister for Irrigation and Power. His inaugural address was short and convincing. He dwelt upon the importance of research work particularly at the present stage of the country's development drive. He pointed out to the research workers the need for developing initiative and originality in pursuing research work. To the elders in the profession, he had a pertinent advice to offer. He observed, 'at some places I find too amuch domineering by the seniors over juniors. As a result the young worker feels dwarfed, and does not show up that much initiative as he would have done had he been brought up as a future hope and not just as a subordinate helper in a laboratory or organisation. I wish our outlook could be changed. We may bring up our young aspirants with the hope that the pupil will surpass the master, just as a father always wishes his son to attain, as high a stature in life as could be possible, irrespective of his own status. That attitude alone is conducive to progress. I feel certain that our Research Organisations will so adjust their method of work as to invoke originality and initiative in the young workers.' Rightly has the Union Minster pointed out this great lacuna in our day to day dealings. It portrays a complex, which we may have developed because of an unwholesome system of administration, permitting spurious distinctions between different services of the States and high-lighting the differences between different services and different grades, still operating in various fields of our national activities. In such an officious atmosphere, class and grade complexes foster and the scientific and research worker, who is unwittingly

Hafiz Mohammed Ibrahim delivering the Inaugural Address. Sri J. S. L. Hathi, Bakshi Ghulam Mohd., Prof. M. S. Thacker, Sri Kanwar Sain, Sir Datar Singh, Mr. Baleshwar Nath may be seen in the picture.

made conscious of his subordinate position, soon looses jest for work. The malady is, therefore, deep rooted and may need vast changes in the administrative set up of the country, so as to bring about necessary reorientation in our existing anachronistic outlook.

Meeting of Minds

Prof. M. S. Thacker presided over the deliberations of the Research Session. Of all the persons in the country, he is most research—minded and today holds the high office of the Director General of the Council of Scientific and Industrial Research. In his Presidential Address, which preceeded the inaugural speech, he presented a general review of the research work done in the country during the year, at different Research Stations in the field of hydraulic engineering and allied subjects. He drew particular attention to the scheme drawn by the Central Board of Irrigation and Power in pursuance of fundamental and basic research. He said that the scheme costing over a crore of rupees now forms part of the Second Five Year Plan and also hinted on some of the procedural difficulties that hinder its progress. He laid special emphasis on the question of minimising evaporation losses from open reservoirs and demineralisation of water at economic cost, particularly in arid and semi arid areas, where mineral salts exist in high concentration. He stated that laboratory experiments are being conducted at the National Physical Laboratory on the fundamental aspects of evaporation control, such as efficacy of different long chain compounds. If these field trials and laboratory investigations prove successful, they may lead a way out to conserve our water resource and release more water for irrgation purposes. Prof. Thacker felt that a climate for scientific research in the country should be created, not with any idea for providing more opportunities for research workers, but with the aim of achieving more results from scientific work-results, which will find practical application and bring economic benefits in terms of our national five year plans. He pointed out that recent announcement of the Prime Minister in the Lok Sabha on the scientific policy of the Government of India was a significant step in that direction. He described it as "the magna carta" of the research scientists and engineers. He said that he artached great importance to such research meetings which he called the meetings of "minds" because they had inherent in them the means for assessing the progress for our research endeavour and for planning collaborative effort of individual and institutional level. He stated that at such conferences factual data and fruitful technique could be shared between participants and integrated into perceptions with creative possibilities.

The business agenda included presentation and discussion of over 40 papers on different aspects of hydraulic engineering and allied sciences. A wide field of subjects was covered. The first subject to be taken up was comparison of model studies with prototype behaviour. The U. P. Research Station presented a paper on Investigation for the hydraulic Design of Sarda Under Sluices and reported that water surface profiles and scour patterns on the prototype were nearly the same as were observed in the model. Prof. N. S. Govinda Rao in an interesting talk explained how cavitation phenomena had been studied with the help of models and discussed the limitations of applying laboratory results to prototypes. Next item was the question of flood protection works including scour and erosion by floods, river training, sedimentation and its control. That invoked considerable discussion. Interesting studies on the training of Yamuna river at Brindaban Ghats, and on the site of the proposed road and railway bridge across Yamuna river

Prof. M. S. Thacker delivering the Presidential Address.

at Delhi were also presented. These were followed by the studies made by the River Research Institute, West Bengal, on the Teesta River model for the proposed Barnes-Domohini embankment and Tilpara river barrage on the Mayurkushi project. The Central Water and Power Research Station laid before the House a revealing and significant study of foundation investigations and laboratory clay grouting on Kotah Barrage. Like other foundation problems it proved of great interest.

Under the head of Materials and their tests, the question of air entraining agents was discussed at length. Attention was focussed on its production with local ingredients on a commercial basis. When the paper on Determining Uplift Distribution under Barrel Portion of canal Syphons as presented by U. P. Research Station was being discussed, Dr. S. K. Roy of Central Water and Power Research Station, Poona, put in an interesting mathematical calculation indicating that what had been arrived at by model studies could be mathematically deduced in a few minutes. Design of spillway bucket at Nagarjunasagar was explained by the Director, Hyderabad Engineering Research Laboratories. The model studies, it was stated, had resulted in adoption of a 70 feet diameter bucket in place of a 90 feet diameter originally proposed and a consequent saving of about, Rs. 12 lakhs in the estimated cost of spillway bucket. The Bihar Institute of Hydraulic and Allied Research presented a study on the assessment of underground water resources in tube well areas in Bihar.

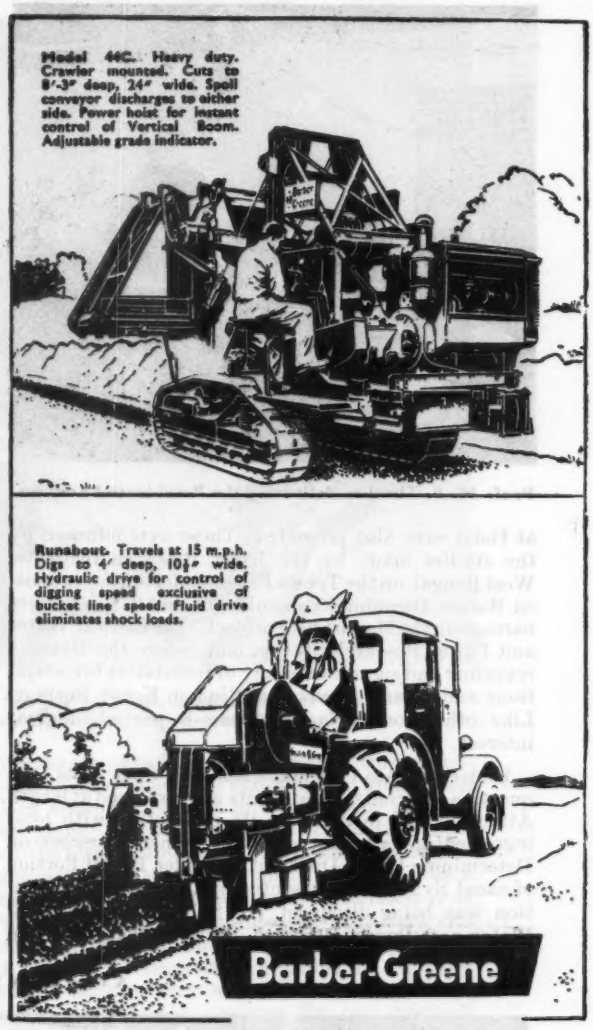
On the Power side, an interesting paper was discussed on penstock block and inlet transition pressure studies on the Vagai reservoir project in Madras. It was stated that the negative pressure at the gate got reduced by 8 feet when flat botttom shutters were replaced by sharp edged ones. Under the head of Hydrology, Dr. L. A. Ramdass presented an interesting paper on "Evaporation Control" and Irrigation and Power Research Station, Punjab presented a study on the sensitivity of water table to irrigation and rainfall in respect of certain tract in Upper Bari Doab Canal Circle. Dr. R. C. Hoon of the Central Water and Power Commission laid great stress for the proper testing of quality of water for irrigation purposes. He suggested a co-ordinated programme of work on quality of irrigation water to be taken up by the States to designate the limits of salinity of water with reference to irrigation applied to normal agricultural land and for purposes of reclaiming deteriorated land. Other subjects discussed included suitability of marine clays for Bombay Harbour for reclamation, relationship of suspended and deposited silt of the rivers, influence of finer sand practions on the properties of concrete and electrical resistivity method applied to sub-soil explorations. The discussions were highly interesting and added considerably to the knowledge of the participants.

A view of the Session in progress.

Kashmir Works

While in Kashmir, the delegates availed of the opportunity of visiting the Mughal Gardens on the intervening Sunday, and also Engineeirng works, far and near, whenever they got spare time to do so. Of special interest was the Mohura Power House on River Jhelum situated at a distance of 54 miles from Srinagar. This is one of the oldest Hydro-electric Power Stations in the country having been commissioned more than 50 years ago. Its wooden conduit channel is unique and presents a wonderful sight in the already picturesque setting of the Jhelum valley. The Power Station building is an excellent masonry structure and though old, it stands out conspicuously. Another project aiming at fuller utilisation of the water drop available in the Jhelum Valley at Mohura is under investigation. The Mohura supplies are being linked up with the newly built Hydroelectric Power Station at Ganderbal in the Sind Valley. On the other side of Srinagar, considerable prospecting for irrigation and power development is going on in the Lidder Valley. A high level contour channel called Maytand canal was taken off many years ago from Lidder river at Ganeshpur a few miles below Pahalgam. This canal is an unique example, how a high level contour canal can serve an extensive area in a river valley. Curiously enough, there are a good number of old irrigation works in the Kashmir Valley. The Awantipure Canal System, Nandi Canals and the recently built Pagdampur lift irrigation scheme, all lie along the road from Srinagar to Anantnag and give the visitor an impression of canal systems normally met with in the plains of Punjab and Uttar Pradesh. Srinagar, itself is a town partly sheltered behind dykes and bunds and affords an interesting study of flood protection measures taken on Jhelum river. Kashmir Valley as a whole is snow bound during winter, is subject to heavy floods during rainy season and needs engineering development on many fronts to attain assured self-sufficiency in food production. Its engineers are making organised efforts to attain the targets. Planned collaboration with the engineers of other States in India, will go a longway in hastening the pace of progress.

An interesting social event of the Conference was the garden party given by the Prime Minister of Jammu and Kashmir to the delegates attending the Conferences. The party was held in the spacious lawns of the Government Emporium, which in the olden days was the Residency building at Srinagar. It was a function attended by all concerned. The atmosphere of cordiality and friendliness that provailed portrayed in full measure the hospitality of Kashmiris. The weather was exceedingly co-operative. But, for little hold up in the air services on account of low visibility over Banihal pass, the means of transport to and fro Srinagar were reasonably convenient. The long road journey between rail-head and Srinagar needing more than a day, will be considerably cut short when the newly built Jawahar Tunnel through the Banihal pass gets into full operation throughout the year. Kashmir though difficult to be approached over-land, is still more difficult to be forgotten. Its rivers and lakes are so beautiful and the natural scenery there is so bewitching that even some who are normally prosaic burst forth into poetry, while singing its praises.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Timber Dam at Sun Valley

Sun Valley, Idaho, world famous winter resort, built and operated by the Union Pacific Railroad Co., is also popular in the summer and other seasons, because of unusual year-around facilities. It is ideally situated in a sheltered valley, 6,000 ft. above sea level in the Sawtooth Mountains of Central Idaho.

Skiing is the principal winter sport, aided by electric powered skilifts, but there is also swimming in warm water pools. During the summer, outdoor sports include ice skating in the new Olympic-size outdoor skating rink, and the regular summer sports, such as golf on mountainside links, fishing, boating, pack trips, etc.

To add to the beauty and recreational facilities, the Union Pacific developed a 10-acre artificial lake within the resort grounds and about 1,000 ft. from the main group of buildings. The water was impounded by a timber dam built in 1937. Today, the dam is still in good condition, after 20 years of service.

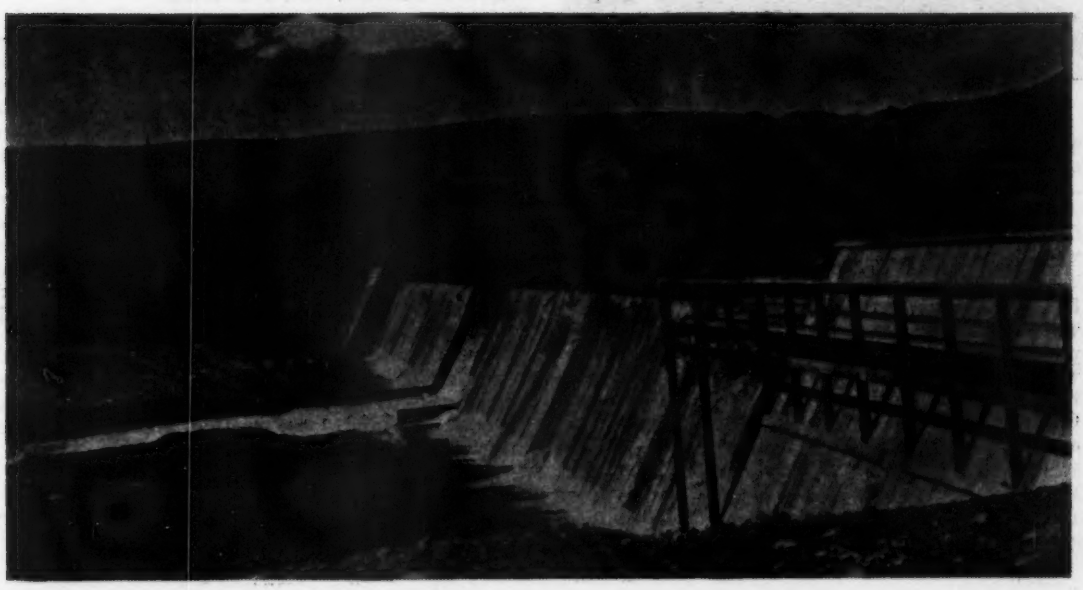
Winston McCrea, manager of Sun Valley Operations, says "To date, maintenance has not been required, but we will shortly need to replace untreated sheathing. The original pressure treated lumber and timbers are in excellent condition."

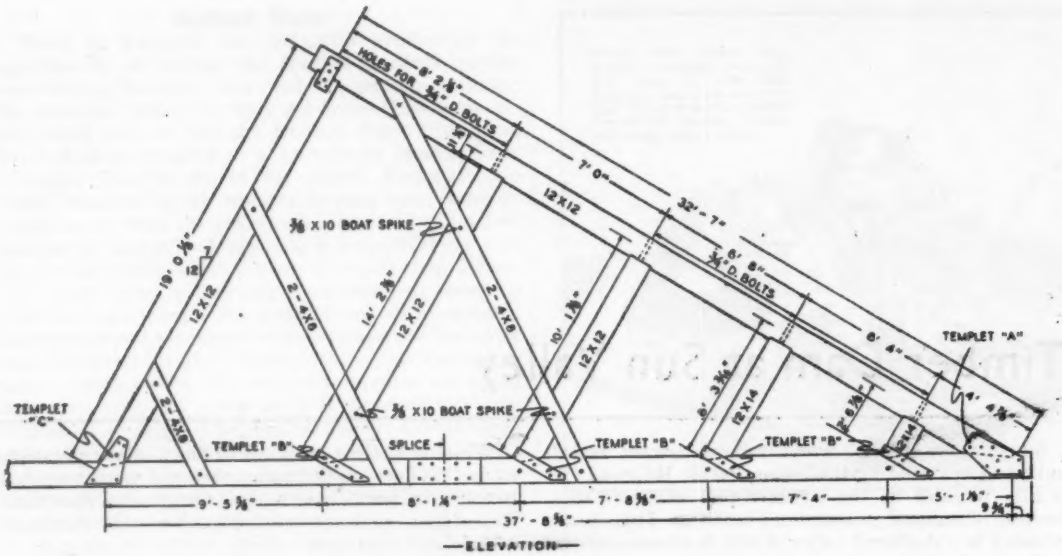
When full to spillway level, the lake has an area of 10.4 acres and a volume of 81 acre feet. The normal flow spillway, 36 ft. long, is about 17 ft. above stream bed. The flood spillway, 300 ft. long, is 1 ft. higher. Abutment end sections are 5 ft. higher.

The first step was construction of a reinforced concrete curtain or cutoff along the upstream face of the dam to a minimum depth of 5 ft. below stream bed and to greater depths where conditions required. The upstream toes of the prefabricated creosoted timber bents were founded on the cutoff wall and the downstream toes on reinforced concrete pedestals.

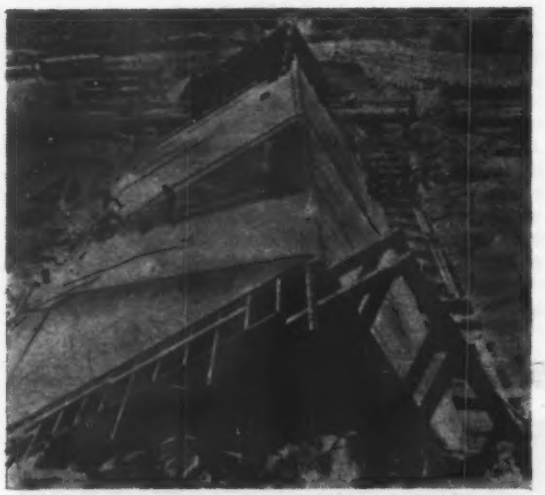
The bents were then sheathed with untreated

Water pours over the flood spillway of dam at Sun Valley. The creosoted timber structure retains 10.4 acres of lake area.





—ELEVATION—



End of flood spillway and start of abutment framing can be seen in fore-ground. The 12×12-in. timber bents each have interior diagonal bracing of 4×8-in. timbers in pairs.
At right background a curved apron takes shape on the downstream toe as workers lay horizontal sheathing over rounded 8×12-in. blocks.
Two layers of sheathing are being laid on the upstream face at left. They are separated by building paper.

lumber to form a hollow dam. Alignment of the dam was obtained by temporarily blocking the frames in place and then pouring the concrete pedestals under the wood sills. Boulder riprapping along the downsteam toe of the spillways completed the main structure. Other features included a fish ladder, an outlet pipe, and a gate.

The framed timber bents, 65 in all, were spaced at 6-ft. centers. Seven different plans were required for these frames because of the three different crest elevations of the dam.

The bent frames were constructed of creosoted 12×12-in timbers, with the exception of two rows of the heaviest loaded bents where 12×14-in. timbers were used in the upsteam face. Diagonal bracing of the bents consisted of creosoted 4×8-in. timbers in pairs. The upstream face has a slope of 12 in 7 ; the downstream slope is 7 in 12. Upstream purlins, to which the sheathing is nailed, are 4×12 in. near the crest and 6×12in. near the upstream toe where deeper water imposes a greater pressure. Over these purlins were laid 2×12-in sheathing plank; followed by a diagonal layer of 1-3/4×5-1/4-in. shiplap. The downstream face was sheathed with 3-in. plank.

To achieve smooth crest on top of the spillways workers rounded an 8×17-in. timber to a radius of 15-1/4 in. through an arc sufficient to match the upper edges of both faces of the dam. To provide suitable curvature for the downstream toe, 8×12-in. timbers 4-1/2 ft. long were framed to provide a 5-1/4-ft. radius for supporting the horizontal sheathing.

All timber used in the dam was Douglas fir incised before pressure treatment. The structural members were also framed, dapped, and bored at the plant before treatment, according to templates. With the exception of the sheathing, all timber was treated with 8 lb. of a creosote mixture per cu. ft.

The plans for this dam were prepared in the Engineering Dept. of the Union Pacific Railroad Co. at Omaha, Neb. At the time of construction, B. H. Parater was chief engineer and G. H. Trout was bridge engineer.

The Inventive Spirit

Mr. K. V. Karantha, former Chief Electrical Inspector, Govt. of Madras, who must be well known to our readers as a contributor to our Journal some years back, has written a neat little booklet under the title "Inventions and Indian Industries*." In this inspiring, almost provocative publication, he has dealt with the problem of promoting a spirit of inventiveness in India. As is well known, the author is a constructive thinker ; consequently, after analysing critically the problem as a whole, he has offered constructive suggestions which deserve the attention of all educated men in this country. It is because of this, that we give more attention to this small booklet than we would otherwise do, had it been just an academic publication.

India is passing through a phase of rapid industrial development, but, unlike the west, this phase has not been preceded by the intellectual-cum-technological fermentation. The author points out that in the absence of this development "we seem to have been almost wholly concentrating on building the body of modern industrial working, while overlooking to create also the spirit of such working". That is why we are more interested in imitating and transplanting the pattern of the west in our country, than inventing and trying to evolve a pattern that would suit our conditions.

The author gives some very interesting examples of this lack of inventiveness. For instance, in the engineering field our P.W.D. Engineers and others are very much concerned about imitating western engineers in building construction, irrigation, bridges, roads etc. There are very few new designs, new experimentations and fresh outlook. For example, "if ever any country needed to discover the principles of earthen dams for conserving river for irrigation, it was a poor country like ours with its teaming millions requiring to be fed. But actually, it was the rich American engineers that developed mud dams for our engineers to continuously imitate". Even in such industries as shelling the paddy, crushing of sugarcane, spinning of jute, decorticating of ground-nuts etc. it was the west that had to do the inventing of suitable machines to do such work mechanically.

The author then goes to analyse how India lacks in the true spirit of modern industrial working. He points out that modern industry in the west was initiated by pioneers who were themselves very great inventors, such as Edison, Arkwright, Goodyear, Singer, Dunlop, Ford, Marconi, Kodak, Ferranti, Crompton, Bell etc., but in our case industries were developed by managing agents who were no technologists. The difference between these two classes of people is indeed very great. If we study the lives of the founders of modern western industrialism, we will find how they concentrated their entire attention and energies to invent new products. They were never satisfied with merely copying existing standards ; they were all the time trying to improve upon them. It is this heritage of continuous search for a perpetual superiority of their products, that is at the basis of modern industrial life of the west. An idea of the impact of this mentality on industrial life can be had when we take into account the fact that in U.S.A. alone "every year some 50,000 patents are taken out and in Britain about 19,000". In our country the comparative figures are 3 to 4,000, "but, of these more than $\frac{3}{4}$ are by foreigners". Patents by Indians come to no more than about 2 or so per million of population, while it is nerely 1,000 per million of population in Switzerland.

There is a general feeling in the country, that, now that a chain of national research laboratories have been established throughout the country, we have the necessary means to rectify out past mistakes. But is this expectation well founded ? Is it not again rather an example of putting the cart before the horse ? In the west they first have the first-rate inventors then and only then the first-rate laboratories. With state sponsoring these laboratories, there is a real danger of the scientists becoming complacent about their own achievement. Even before these national laboratories were set up we had several similar institutes like the Indian Institute of Science at Bangalore. To what extent have such institutes staffed by Ph.Ds and M.Scs working over many decades been able to produce ? Then again our laboratories are not organically related to the growth of our industries as in the west. Most of our scientists and research staff have no direct experience of the industrial problems *in India*. But, they have a background of industrial establishments in the west, which are not yet existent in this country. Thus they lack the practical bent of mind and have an academic attitude of research. How can they then lay the foundation for industrial research in our country ?

We have also a peculiar attitude to research. We have come to believe that research can be undertaken only by experts, and in the most modern laboratories. But, except in certain fields, such as in chemical industries, the spirit of inventiveness can be expressed in the form of applied research by a very large number of individuals working in the industries, and closely related to the day to day problems of production, whether such persons have academic qualifications and foreign degrees or not. It is this prevailing mentality that has further circumscribed the incentive to applied research.

The author then suggests some concrete steps that should be taken by the Government and the educational authorities in order to create an atmosphere of inventiveness and to encourage larger number of individuals to come forward with confidence, with fresh ideas and experiments dealing with concrete problems.

*"Invention and Indian Industries" by Mr. K. V. Karantha, published by Newspapers Publishers Private Ltd., Rodialbail, Bangalore-3. Price Rs. 3/-

May we ask our readers to go through this little book and spread this message of national regeneration based on selfconfidence and the spirit of enquiry in the individual rather than on material things.

* * *

Our attention was drawn to the resolution adopted at the public meeting held under the Chairmanship of the eminent scientist Dr. D. M. Bose, in July, '58. This relates to the serious situation created by the rapid deterioration of the Bhagirathi-Hooghly River system, specially with reference to :

1. the navigable sea-route from the Port of Calcutta.
2. the water supply system of the city of Calcutta and its industrial suburbs containing a population of more than 10 million people, and
3. the drainage conditions of the five most prosperous districts of West Bengal, Murshidabad, Birbhum, Burdwan, Nadia and 24-Parganas and thereby exposing them to increasing flood hazards.

It has been known for a long time that the only solution to these problems lies in the construction of the Ganga Barrage. This has been confirmed by even the latest report of the experts. We hope that the authorities concerned will take urgent steps to that effect.

It is also important that a Ganga River Board should be constituted at the earliest, so that all the various projects based on the Ganga and its tributaries may be scrutinized from the point of view of the basin as a whole, before they are sanctioned for execution. It is only in this manner that conflicting interests pertaining to the waters of the Ganga can be satisfactorily resolved. We have been pleading for such a basin-wise approach for a long time. Now that conflicting interests are emerging, particularly based on the Ganga, we hope that the authorities will lose no time in facing the problem squarely and to the satisfaction of all parties concerned.

Progress of Electrification in French Africa

Continued from page 24

to 150,000 kW and production to 1.3 billion kWH; the building of 2 large power plants at Konkouré in Guinea (approved by a deliberation of the ministers' council in October 1957) with a 400,000 kVA capacity and a production of 3 billion kWh, and at Kouilou (one millior kVA and 7 billion kWh).

Distribution Problems

The scope of these projects should not blur the fact that the ultimate goal is ever the comfort of the African peoples through higher living standards. For this reason, even though it may be relatively easy to plan and build industrial complexes in Africa, the problems of distribution, which are comparatively simple in heavily urbanized countries, is particularly difficult in Africa. In Brazzaville, for example, 2,000 consumers are spread out over an area roughly that of Paris, where there are over one million consumers. These two figures illustrate the difficulty of the problem. The high cost of high-tension cable, with inevitable losses, make it hard for power plants to service sparsely populated areas. Each region is obliged more often than not to use power produced locally. Under these circumstances, French manufacturers have endeavored to develop electric equipment especially adapted to reduced needs, notably by creating standard type electric power plants which are complete installations in themselves, including Diesel generator groups and everything necessay for long-term operation. This equipment is both simple and sturdy. Particular attention was given to the watercooled refrigeration system for temperatures up to 45 degress C (114°F.).

With technical problems solved, those responsible for social policy in the overseas territories have been able to turn their endeavor to electrifying numerous second-rate comunities and even rural areas. In French West Africa, the number of subscribers doubled from 1952 to 1955. Consumption has followed the same upward curve as has production, rising from 32 million kWh in 1949 to 97.5 million in 1955. Of this latter, domestic consumption (low tension) amounts to 42.6 million, and industrial consumption (medium tension) to 54.9 million.

Electrification is a major keynote of economic and social progress in the French overseas territories both from the standpoint of industry and that of private consumption. New developments in both fields are yet forthcoming, and the theory of doubling electric production every 10 years, already confirmed in heavily industrialized countries, is becoming a 5-year theory in the overseas territories. This is borne out by the 12 to 13 % annual increase already noted. The success of the first two equipment plans in this particular realm has been confirmed by these statistics.

Our Contributors

Mr. P. R. Sundaram is Deputy Chief Electrical Engineer, Bihar State Electricity Board with 25 years experience in power development in Madras and Bihar.

Mr. J. Hoffman is an engineer in the Dam Branch of the Bureau of Reclamation, U.S.A.

Mr. W. E. Collins is also an engineer in the Dam Branch of the Bureau of Reclamation, U.S.A.

Mr. R. L. Phansalkar is a retired Executive Engineer from Bombay State, and is a frequent contributor to this Journal.

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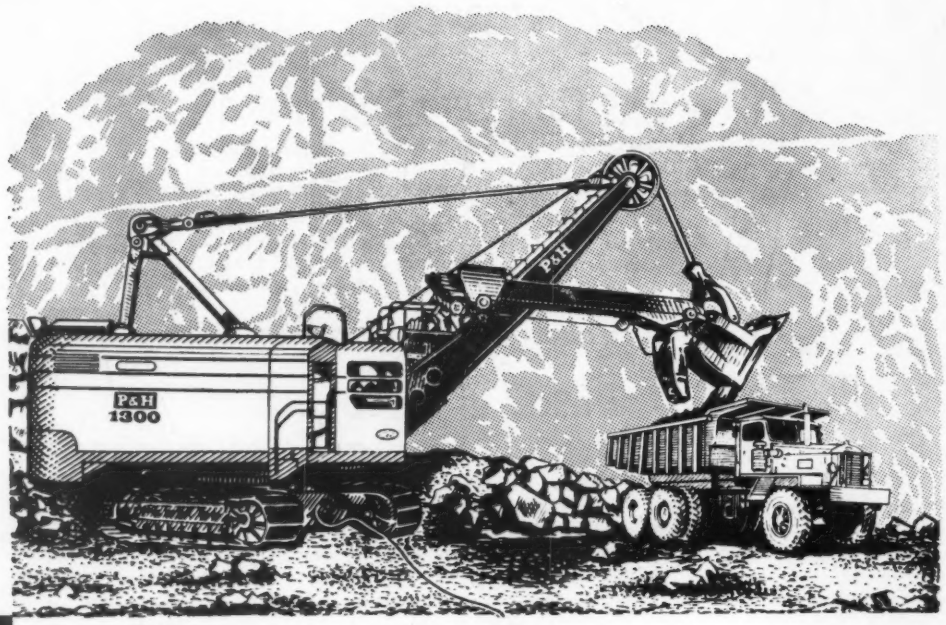

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